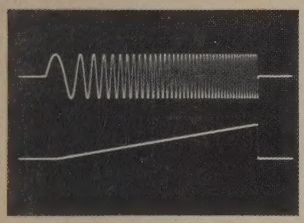
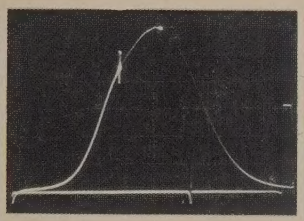
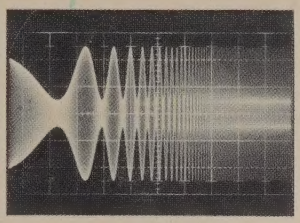
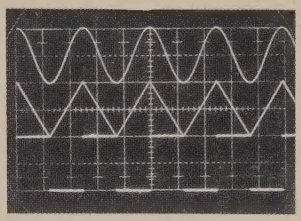
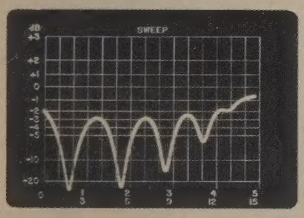
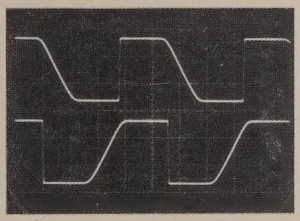
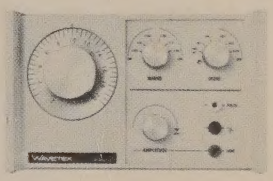
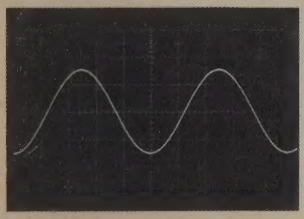
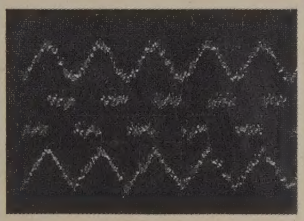
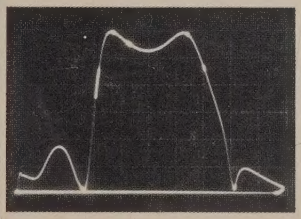
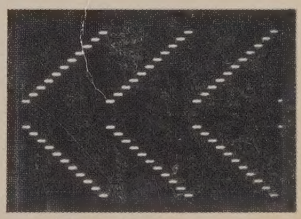
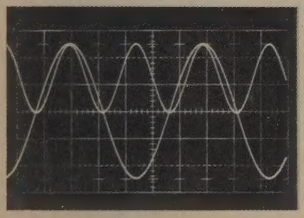
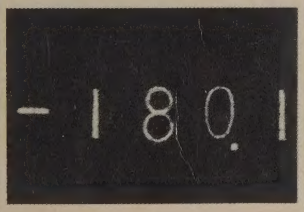
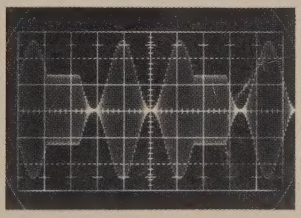
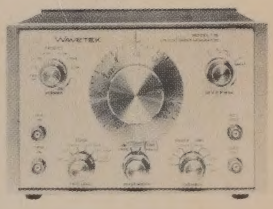
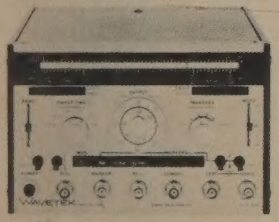
WAVETEK GENERATION AND MEASUREMENT EQUIPMENT

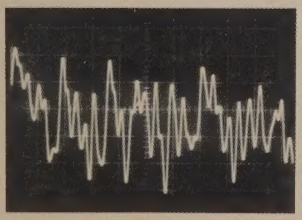
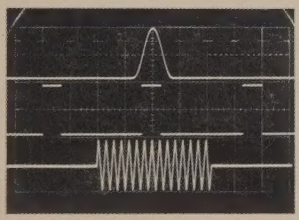
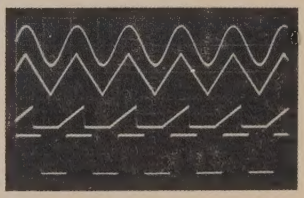
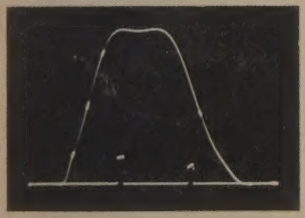
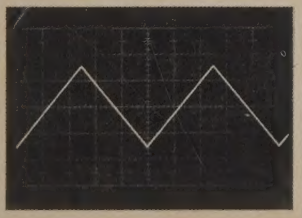
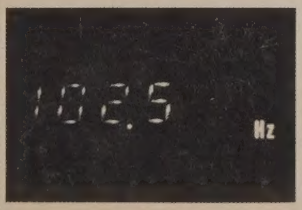






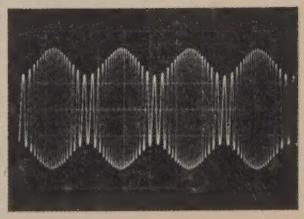
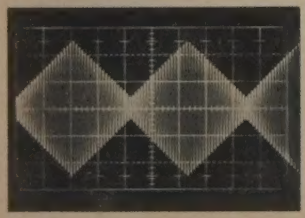
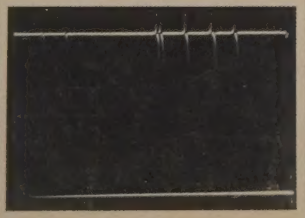
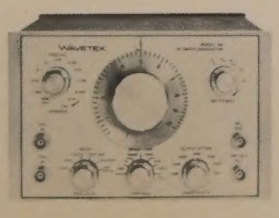



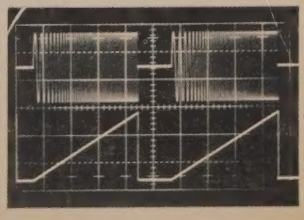











HOW TO USE THIS CATALOG

This catalog is designed to help you select and order instruments from Wavetek's line of generation and measurement equipment. In addition to providing complete descriptions and specifications on more than 50 instruments, the catalog contains several indexing methods that will make your job easier. For example:

- If you're interested in a specific technical feature, you can find it by referring to the Subject Index on page 78.
- If you're looking for a particular Wavetek instrument, you can find it quickly in the Model Number Index on page 80.
- If you're just checking out instruments in general, the Table of Contents gives you a brief description of features and capabilities within each instrument category.
- If you need more assistance or a demonstration, check pages 74, 75, 76 and 77 and contact the Wavetek representative nearest you. Or contact Wavetek direct.

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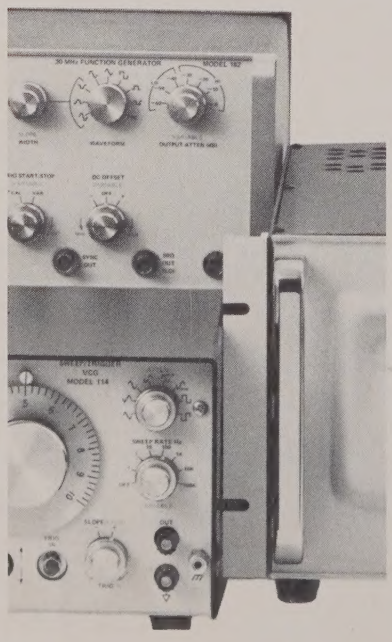
CONTENTS

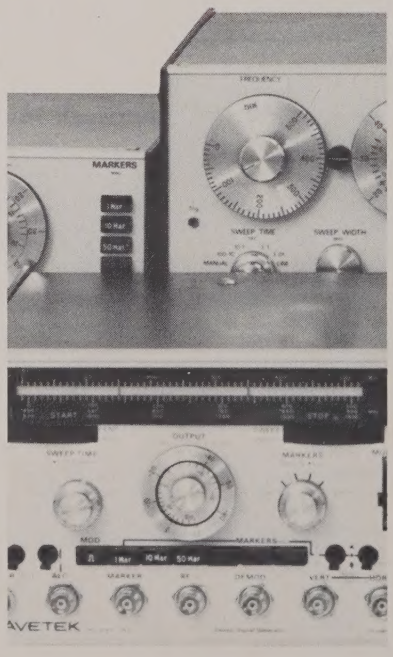
FUNCTION AND SWEEP/FUNCTION GENERATORS

Function generators are precision sources of multiple waveforms controlled over a wide range of frequencies. Frequency ranges vary from 2 μHz to 30 MHz. Waveshapes are primarily sine ∿, triangle △, and square wave ⊓ with many other variations available. Each instrument offers unique features which can be matched to a particular requirement.



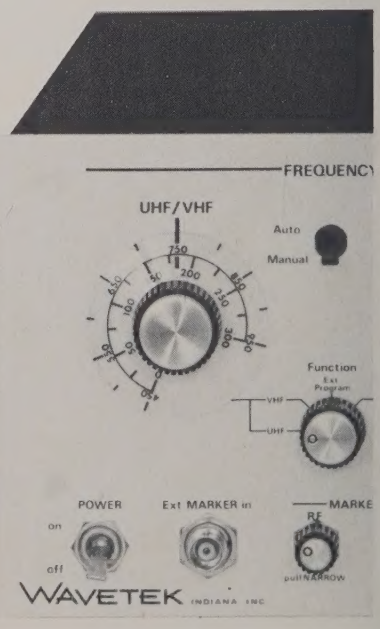
SWEEP/SIGNAL GENERATORS

Sweep/Signal generators provide a high frequency signal which may be swept over a controllable band of frequencies. These generators are also usable as fixed frequency devices and cover the range from less than 1 MHz to 1400 MHz. Excellent linearity, amplitude control and flatness over the operating range are key features of these instruments. High quality detectors, attenuators and display oscilloscopes are also available for systems manufacturers.



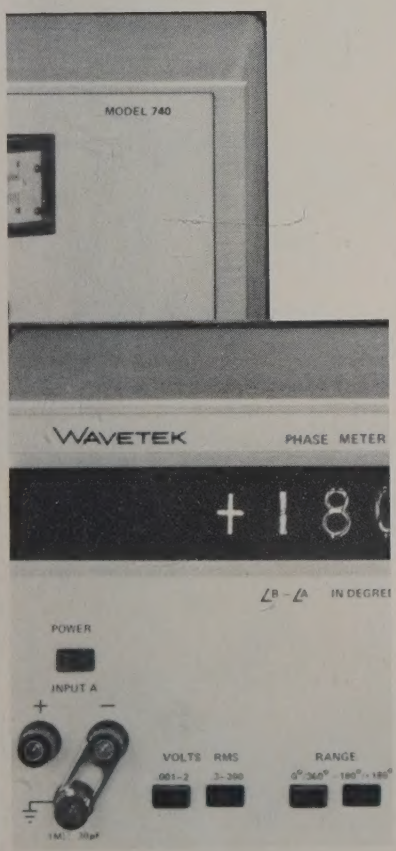
TELEVISION TEST EQUIPMENT

Television test equipment consists of sweep generators and related equipment used in the production alignment of TV and FM receivers. These instruments accept a variety of optional features for rapid receiver alignment, test and evaluation.



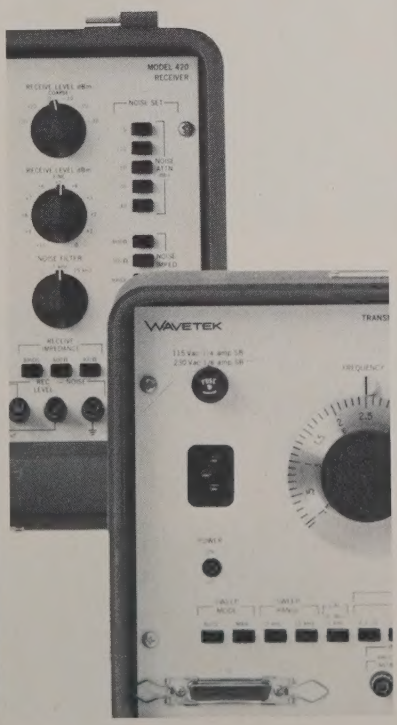
PHASE METERS

Phase meters accurately measure the phase angle between any two signals of the same frequency without regard to amplitude differences. A dc output proportional to phase difference can be used to record measurements or as a control signal for phase lock loops or servo systems.



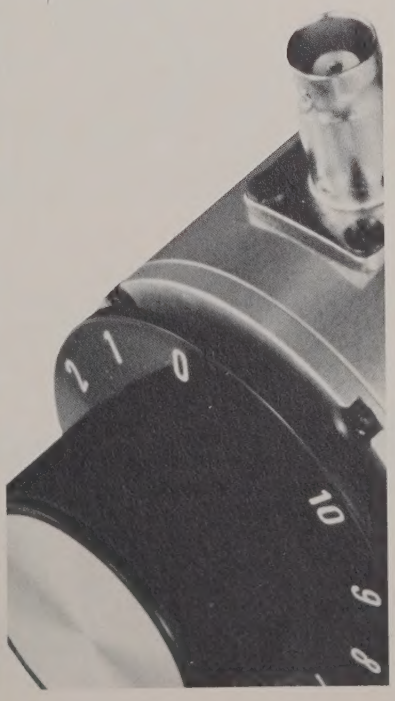
TRANSMISSION LEVEL TEST SET

The transmission Level Test Set or level tracer is a portable instrument which allows level and impedance measurements across the voice and program frequency ranges from 50 Hz to 15 kHz.



ACCESSORIES AND OPTIONS

Variations may be special ordered for almost all models, and some instrument applications may be enhanced by accessories. In general, accessories and options that are peculiar to an individual instrument are listed with the instrument. General accessories and options, such as rack adapters and custom rack mounts, are in this section of the catalog.



INTRODUCTION

One of the greatest changes taking place in this era of great change is the influx of electronics into virtually every field of endeavor. While there have been some spectacular achievements in the development and application of electronic technology, much of the progress has come from the myriad small advances made daily by the thousands of engineers and technicians using the basic tools of their trade. Among these tools are Wavetek's general-purpose test and measurement instruments. In addition to serving as fundamental tools in the electronics industry, Wavetek instruments are now being used in many diverse fields that require sources of precise electrical stimuli.

Wavetek was founded in 1962 with one product, the Model 101 Function Generator, a staff of two, and an optimistic outlook for the future. It is now evident that the optimism was well-founded.

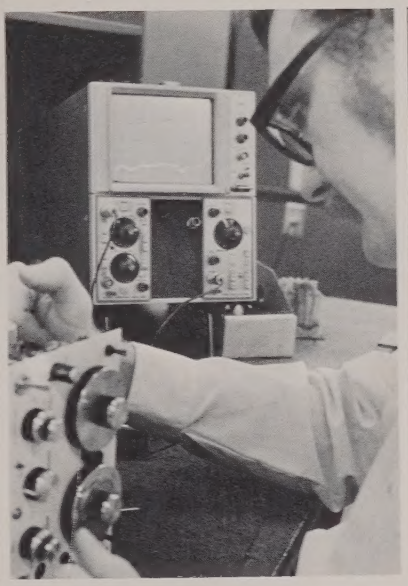
Today, from plants in San Diego and Indianapolis, Wavetek sells throughout the world more than 60 different products in the general-purpose test and measurement field, special-purpose equipment for TV production, and computer data communications equipment.

During its relatively brief history, Wavetek has done much more than expand its product line and its payroll. The major effort has been to innovate — to make fundamental improvements in competitively priced instruments — through objectivity in design, honesty in specifications, and integrity in business. The result has been several significant technical contributions to a complex and demanding industry.

One such contribution was the first voltage controlled generator — or VCG — a designation that has become almost generic in its use. In the field of sweep generators, Wavetek's unique voltage control circuitry allows automatic sweep, attenuation, or programmable testing that saves time and labor at lower instrument cost.

Throughout this process of technical innovation, Wavetek has been vitally concerned with quality. Not only is quality designed into every Wavetek instrument, it is precisely controlled at every stage of manufacturing, test, and inspection. This is why each instrument is backed by a strong written warranty.

WAVETEK



FUNCTION AND SWEEP/FUNCTION GENERATORS

MODEL GROUPS

110 Series **Page 10**

Six models with time proven reliability. One MHz upper frequency. From the simple low cost model to models with many features including voltage control of frequency, battery operation, and sweep.

120 Series **Page 42**

Four modules, each a portion of a function generator. Offered separately or in three circuit card function generator configurations. To 100 kHz and with sweep and trigger.

130 Series **Page 14**

Seven models with a 0.2 Hz to 2 MHz range plus a LF model of 2 μHz to 200 kHz. From a simple low-cost model to models with many features including noise, sweep, and voltage control of amplitude and frequency.

140 Series **Page 22**

Four models with a 0.0005 Hz to 10 MHz range, waveform symmetry control, voltage control of frequency, and many other features.

150 Series **Page 28**

The programmables, four BCD parallel input models and three ASCII serial input models, with and without local control panels.

160 Series **Page 38**

Two models with a 30 μHz to 30 MHz range, voltage control of frequency, fully adjustable waveforms including rise and fall times. One model with linear and step sweep.

Model 30 **Page 44**

A low-cost, many featured sweep/function generator. Light weight and battery powered, it is ideal for portable as well as laboratory use.

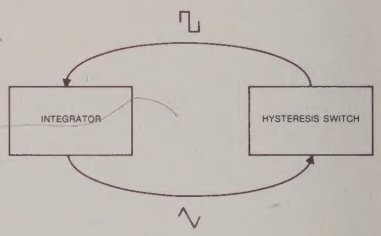
INTRODUCTION TO FUNCTION GENERATORS

Function generators produce various electrical signals that can be varied in frequency, amplitude and waveshape. The time for one cycle of signal can be as slow as 138 hours to as rapid as three hundredths of a millionth of a second. The peak-to-peak signal voltage may be varied from 30 volts to a thousandth of a volt, by manual or programmable control and by amplitude modulation. The signals can be continuous or triggered and their start and stop points along the ac waveform may be varied. External signals, as well as manual controls, can turn outputs on and off, vary the frequency and amplitude, and even program entire generators.

There is an amazing variety of applications for function generators as well as a variety of fields in which they are used. They are used for testing, calibration, triggering, and simulation of physical and biological functions. They are used in electronic design, chemical analysis, geophysical investigation, biomedical research, and structural testing. To meet these needs, 27 models combining various features are offered. Wavetek regularly publishes an application booklet, *Waveteknique*, that describes some of these applications. The *Waveteknique* can be obtained from your nearest Wavetek representative.

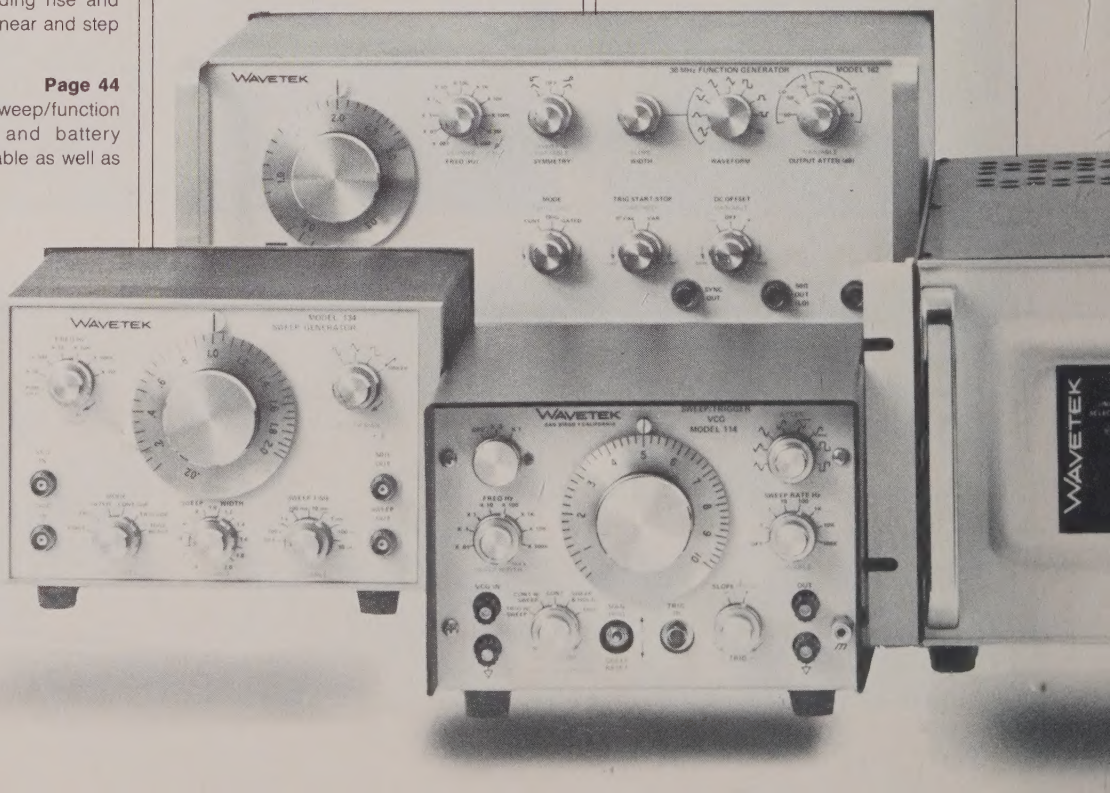
The Basic Function Generator

Some functional blocks are common to all Wavetek function generators regardless of the complexity of the final product. The basic function generator has a nonlinear feedback loop consisting of an integrator and a hysteresis switch.



These basic blocks operate on each other to produce the waveforms indigenous to the function generator, namely, the *square and triangle waves*. Notice that the triangle results from the integrator's operation on the square wave, and the square wave results from the hysteresis switch operation on the constant-slope segments of the triangle wave.

The third waveform usually produced by function generators is the sine wave. It is not naturally produced by the function generator loop, as it is in a harmonic oscillator; it is the result of a shaping process on the triangle wave by a non-linear diode or transistor network. This sine-shaping network produces total harmonic distortions as low as 0.25% when operating at moderate frequencies.



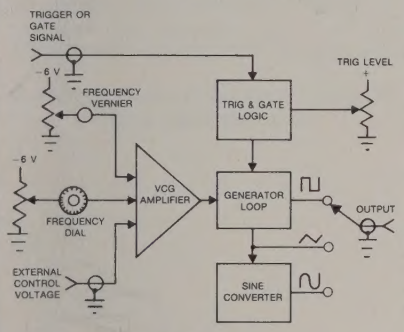
From this fundamental loop, waveforms with remarkable acuity in amplitude flatness, square wave rise times, frequency control linearity, and independence from temperature and frequency are produced.

Voltage Controlled Generator (VCG) (All models except 110 and 130)

In 1964, Wavetek revolutionized low frequency sweep testing with the introduction of the first all electronic, *voltage controlled generator (VCG). Sweeping* is the varying of the output signal frequency at a predetermined rate.

In the VCG diagram, the current source for the generator loop can be varied by the VCG amplifier and is determined by the sum of the input voltages from the main frequency dial, vernier dial, and external input. The current amplitude, in turn, controls the frequency of the triangle wave created by the integrator and, thus, controls the frequency of the function generator loop. The frequency may be controlled by externally supplied dc or modulated by external ac; in addition, the frequency may be set by the main dial and set even more precisely by an electronic vernier control.

The response of the voltage controlled generator is limited only by the bandpass of the VCG amplifiers.



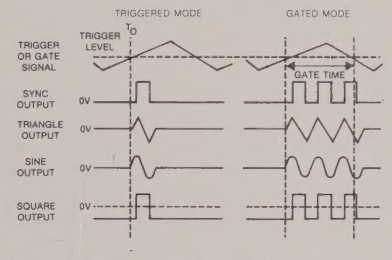
VCG and Trigger

Triggering and Gating (Models 112, 114, 116, 133, 134, 135, 144, 146, 147, 162, 164, 150, 154, 155, 157, 158, 159)

A natural advantage in generating waveforms with a Wavetek instrument is that the closed loop contains no tuned circuits. Consequently, when a signal is applied at the proper point in the loop, the circuit reacts immediately, with no twanging or ringing. No settling time is required. Thus triggering and gating modes allow the function generator to generate exactly one cycle or a specific number of cycles.

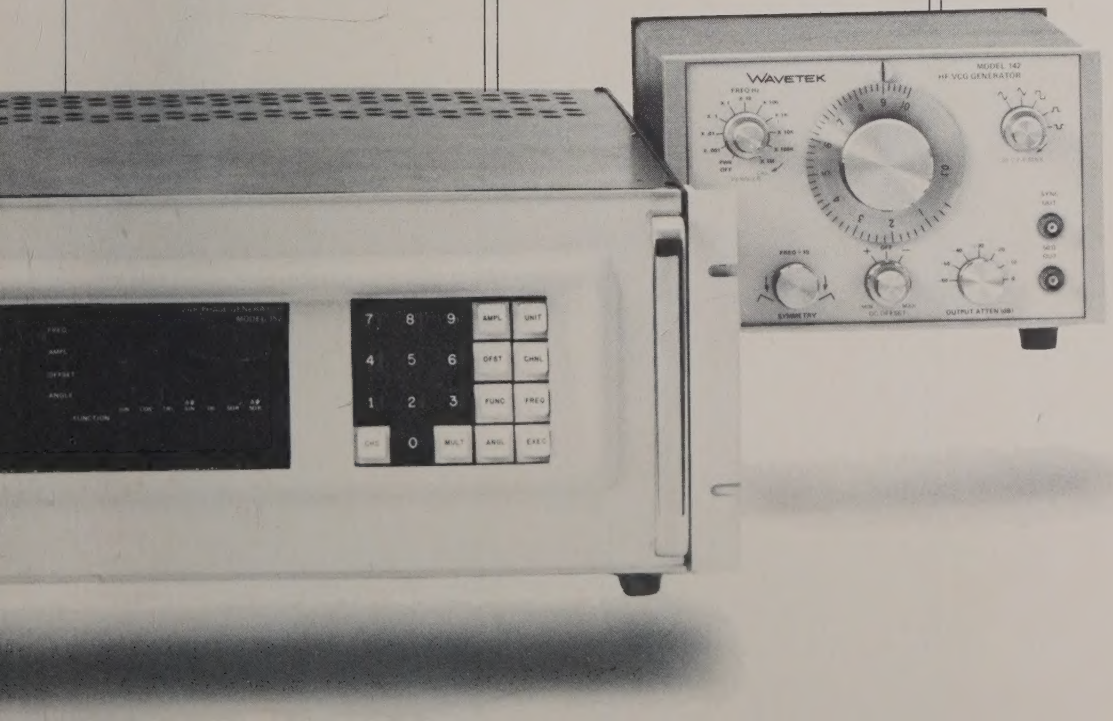
A *trigger* is a signal that causes one cycle of output regardless of the duration of the trigger itself. A *gate* is a pulse that, when it reaches a predetermined level, causes a continuous output from the generator until the pulse drops below that level. A *trigger-level control* determines this level and allows discrimination against undesirable low-level pulses when triggering or gating.

Gated signals are referred to as *tone bursts* and have their greatest application in testing electro-acoustical devices such as transducers, speakers, sonar circuitry, and detector and rectifier circuits. Triggered cycles are often used in conjunction with specially shaped low frequency waveforms to simulate physical phenomena such as simple harmonic motion, heartbeat and nerve response.



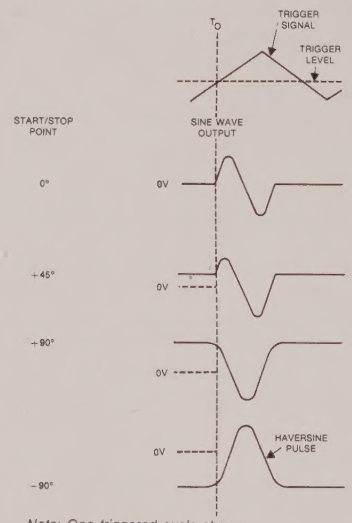
Note: Any cycles started during gate time are completed, even if the gate signal drops.

Trigger and Gate



Waveform Shaping

Start/stop point control (Models 112, 114, 116, 133, 162, 164) allows the instrument oscillation to be started and stopped at a given point, or phase, of a waveform. This feature is often used in conjunction with dc level control to create special triggerable waveforms such as the *haversine* pulse.



Note: One triggered cycle shown.

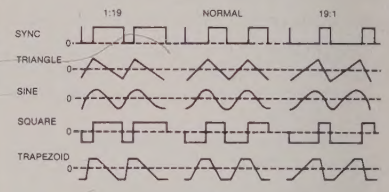
Effect of Start/Stop Control

DC offset control (Models 113, 152, 154, 158, 159, and all 130, 140, and 160 Series) allows the dc level of the output signal to be varied in order to accommodate given test requirements. On many instruments, the control also sets a *dc output* level.

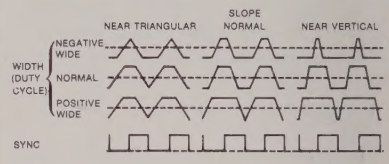
The normal *horizontal symmetry* of the output waveform is a 1:1 ratio of positive half cycle to negative half cycle or pulse on time to off time. This cycle ratio may be fully varied from 19:1 thru 1:1 to 1:19 by *symmetry control* (all 140 and 160 Series). Triangle waveforms are changed to sawtooth, square waveforms to very narrow pulses of either polarity, the sine waveforms to distorted sinusoidal waveforms, and trapezoidal waveforms to asymmetrical waveforms in which rise and fall times are different.

The *trapezoid waveform* (Models 162, 164) is a truncated triangle waveform. Trapezoid *rise and fall times* are varied by varying the ratio of triangle amplitude to width. This is done with *slope and width control.* Rise and fall durations can be as short as 12 ns (near vertical) and continuously increased until the trapezoidal waveform becomes triangular.

When slope control is used in conjunction with symmetry control, rise and fall times of the trapezoidal waveform can be individually tailored for such applications as comparator evaluation, measuring core memory drive response, measuring amplifier response time, and minimizing switching transients.



Symmetry Control



Trapezoid Waveform Variations by Use of Slope and Width Control

Internal Sweep (Models 30, 114, 134, 135, 144, 146, 147, 164)

Sweep/function generators are actually two generators in one. The main generator is a VCG while the secondary generator usually produces a *sawtooth waveform* which can sweep, VCG fashion, the main generator. Besides the *linear sawtooth,* a *logarithmic sawtooth* is available as is a *staircase waveform* of many discrete steps. *Stepped sweep* can be for set durations at each step and stepped automatically, or stepped by pressing a switch when a change in frequency is desired.

Start and stop frequencies and sweep duration are fully adjustable. Sweeping can be from low frequency to high frequency or vice versa. The output signal may be swept repeatedly or triggered for a sweep and return to start frequency. Or, the output may be gated for sweep and the output held at the final swept frequency until the gate signal falls; this is called *sweep and hold.*

In *sweep burst* (Model 164) mode, the output signal is a dc level until the generator is gated. When gated, the generator is swept until the gate closes or, if the gate time exceeds the sweep time, swept to the final frequency and held at that frequency for the duration of the gate.

Generator Control Voltage (GCV) (Models 30, 135, 144, 146, 147, 164) output is a voltage proportional to the main output signal's frequency. During sweeping, GCV can be used as a horizontal drive for an oscilloscope or X-Y recorder to create a display or graph in the frequency domain.

Phase Lock (Models 116, 152)

The phase locking feature allows the generator to lock to an external signal frequency and to maintain a given phase relationship to that signal.

Noise (Model 132)

Pseudo-random noise can be an analog noise or a digital sequence. The clock rate of the digital noise is selectable as is the bandwidth of the analog noise. The sequence length of the random signal is selectable. The standard sine, triangle, and square waveforms may be noise modulated in *signal-to-noise* (S/N) and *noise-to-signal* (N/S) modes of fully selectable ratios. Because systems of all types experience random disturbances (noise) it is advantageous to test them with pseudo-random noise, noise that can be both measured and repeated. Pseudo-random noise is used to test high speed switches in logic circuits, silicon controlled rectifiers, wind turbulence effects on rockets, bridges, antennas; temperature-fluctuation effects on temperature control systems; and speech effects on communication systems.

Programmable & Digital Control (All 150 Series)

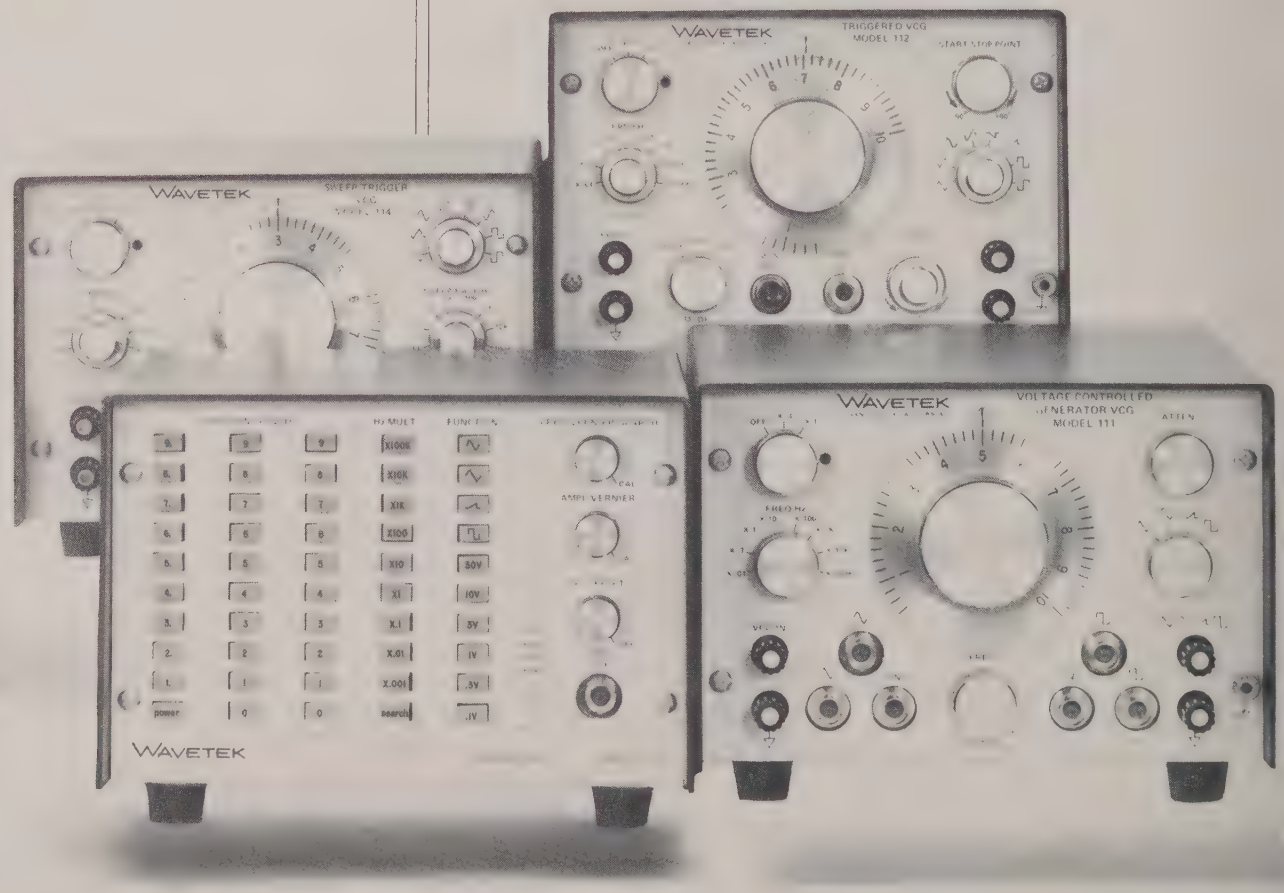
Programmable and digital control uses the instantaneous response of the VCG to its greatest advantage. Frequency, function and amplitude may be changed swiftly and accurately by the touch of a button or application of a remote digital input. Digital control lends itself to repetitive testing and to automatic systems where the stimulus is automatically selected and must be accurately repeatable.

SERIES 110 FUNCTION GENERATORS

The Wavetek 110 Series offers a broad range of function generator features. These instruments are unique in their rugged construction, multiple simultaneous output capability, and battery power supply for line-free operation and portability. The Model 110 provides simplicity of operation with its sine, triangle, square, and sync waveforms. The Model 111 adds external dc and ac modulation capability (VCG). Triggered and gated operation are added in the Model 112. For applications where repeatability is needed, the 113 provides digital push button operation. For internally provided sweeping the 114 is the answer. Sweep width of up to 100:1 is available. Tone burst and phase lock are features of the Model 116.

SELECTION GUIDE

Features	Model 110	111	112	113	114	116
Basic Waveforms	X	X	X	X	X	X
180° Phase Shifted	—	—	X	—	X	X
Ramp	—	X	X	X	—	X
Positive Offset Sine	—	—	X	—	X	X
Negative Offset Sine	—	—	—	—	X	—
Haversine Pulse	—	—	X	—	X	X
Internal Sweep and Sweep Output	—	—	—	—	X	—
Internal Tone Burst	—	—	—	—	—	X
VCG for Frequency Modulation	—	X	X	X	X	X
Upper Frequency (MHz)	1	1	1	1	1	1
Lower Frequency (mHz)	5	1.5	1.5	1	1.5	1.5
Attenuation (dB)	30	30	30	70	50	30
Amplitude Control and Vernier	—	—	—	X	—	—
Triggering and Gating	—	—	X	—	X	X
Phase Lock	—	—	—	—	—	X
Adjustable Waveform Start/Stop Points	—	—	X	—	X	X
DC Offset	—	—	—	X	—	—
Battery Power Option	X	X	X	—	X	X
Push Button Controls	—	—	—	X	—	—



MODELS 110/111 FUNCTION GENERATORS

Model 110

This function generator is a calibrated high-purity source of sine, square, and triangle waveforms. It operates at servo, audio, and video frequencies with six simultaneous outputs. Its rugged construction, compact size, and precision operating characteristics make the Model 110 a portable laboratory of test signals in one economical package.

Note: In the following specifications, "B" denotes battery version.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, and sync pulse.

Frequency Range

0.005 Hz to 1 MHz.

Simultaneous Outputs

6 (5 fixed, 1 variable amplitude).

Output Level

Variable: 30 V p-p max into 600Ω; 10 V p-p max into 50Ω (110B: 5 V p-p into open circuit).

Fixed: 5 V p-p into open circuit; 2.5 V p-p into 50Ω.

Output Impedance

Variable Output: 50Ω (600Ω available); 110B, 600Ω.

Fixed Output: 50Ω.

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale, 0.005 Hz to 100 kHz.
±2% of full scale, 100 kHz to 1 MHz.

Time Symmetry

99.5% for 0.005 Hz to 100 kHz.
99.0% for 100 kHz to 1 MHz.

Jitter

0.025% cycle to cycle.

VERTICAL PRECISION

Frequency Response

0.1 dB for 0.005 Hz to 100 kHz.
0.5 dB for 100 kHz to 1 MHz.

Stability

0.05% for 10 minutes.
0.25% for 24 hours.

PURITY

Sine Wave Distortion

0.5% for 0.005 Hz to 10 kHz.
1.0% for 10 kHz to 100 kHz.
3.0% for 100 kHz to 1 MHz.

Triangle Linearity

99% for 0.005 Hz to 100 kHz.
95% for 100 kHz to 1 MHz.

Square Wave Rise and Fall Time

Fixed Outputs: Less than 15 ns.
Variable Output: Less than 100 ns.

Total Aberrations

Less than 5% with proper termination.

ENVIRONMENTAL

All specifications apply for 25°C ±5°C.

MECHANICAL

Dimensions

7¾ in./19.7 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

7 lb/3.2 kg net, 12 lb/5.45 shipping.

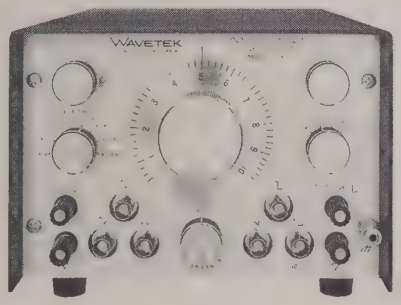
Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 10 watts. Ni-cad batteries and built-in charger furnished with 110B.

ORDER INFORMATION

(FOB San Diego)

Model 110	**$495**
Model 110B	**$645**



Model 111

The 111 VCG is a precision source of sine, square, triangle, and ramp waveforms. It offers control of frequency by external voltage — either dc programming or wide band ac frequency modulation. The instantaneous frequency of these waveforms is determined by the combination of the dial setting and the externally applied voltage. The VCG input is parallel with the frequency dial. Actually, the Model 111 VCG is a portable oscillator, square wave generator, FM modulator, frequency shift keyer, and sweep generator — all in one economical package.

Note: In the following specifications, "B" denotes battery version.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, ramp ◿, and sync.

Frequency Range

0.0015 Hz to 1 MHz.

Simultaneous Outputs

7 (6 fixed, 1 variable amplitude).

Output Level

Variable: 30 V p-p max into 600Ω; 10 V p-p max into 50Ω (111B: 5 V p-p into open circuit).

Fixed: 5 V p-p into open circuit; 2.5 V p-p into 50Ω.

Output Impedance

Variable Output: 50Ω (600Ω available); 111B, 600Ω.

Fixed Output: 50Ω.

VCG — Voltage Controlled Generator

Frequency may be dc-programmed or ac-modulated over a 20:1 range.
Linearity: 0.1% (10% to 100% of dial only).
Bandwidth: 100 kHz.

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale, 0.0015 Hz to 100 kHz.
±2% of full scale, 100 kHz to 1 MHz.

Time Symmetry

99.5% for 0.0015 Hz to 100 kHz.
99.0% for 100 kHz to 1 MHz.

Jitter

0.025% cycle to cycle.

VERTICAL PRECISION

Frequency Response

0.1 dB for 0.0015 Hz to 100 kHz.
0.5 dB for 100 kHz to 1 MHz.

Stability

0.05% for 10 minutes.
0.25% for 24 hours.

PURITY

Sine Wave Distortion

0.5% for 0.0015 Hz to 10 kHz.
1.0% for 10 kHz to 100 kHz.
3.0% for 100 kHz to 1 MHz.

Triangle and Ramp Linearity

99% for 0.0015 Hz to 100 kHz.
95% for 100 kHz to 1 MHz.

Square Wave Rise and Fall Time

Fixed Outputs: Less than 15 ns.
Variable Output: Less than 100 ns.

Total Aberrations

Less than 5% with proper termination.

ENVIRONMENTAL

All specifications apply for 25°C ±5°C.

MECHANICAL

Dimensions

7¾ in./29.7 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

7 lb/3.2 kg net, 12 lb/5.45 shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 15 watts. Ni-cad batteries and built-in charger furnished with 111B.

ORDER INFORMATION

(FOB San Diego)

Model 111	**$595**
Model 111B	**$745**

MODELS 112/113 FUNCTION GENERATORS

Model 112

This function generator provides all the versatility of multiple outputs and VCG in the Model 111 and adds the ability to trigger one cycle or gate a tone burst from a front panel control or an external pulse. In the gate mode, an external gate signal allows tone bursting. Trigger start/stop point is selectable over 360°. Trigger level and polarity are selectable from front panel control.

Note: In the following specifications, "B" denotes battery version.

VERSATILITY

Waveforms

Sine, square, triangle, ramp, sync, plus 180° phase shifted.

Frequency Range

0.0015 Hz to 1 MHz in 16 overlapping ranges.

Simultaneous Outputs

9 (8 fixed, 1 variable amplitude).

Output Level

Variable: 30 V p-p max into 600Ω; 10 V p-p max into 50Ω (112B:5 V p-p into open circuit).

Fixed: 5 V p-p into open circuit; 2.5 V p-p into 50Ω.

Output Impedance

Variable Output: 50Ω (600Ω available) (112B: 600Ω.)

Fixed Output: 50Ω.

Trigger/Gate Input Requirements

Voltage: ±5 V min.; ±100 V max.

Impedance: 10 kΩ (also front panel control).

VCG — Voltage Controlled Generator

Frequency may be dc-programmed or ac-modulated (FM) over 20:1 range.

Linearity: 0.1% (10% to 100% of full scale).

Bandwidth: 100 kHz.

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale, 0.0015 Hz to 100 kHz.
±2% of full scale, 100 kHz to 1 MHz.

Vernier Accuracy

One turn for 1% change of full scale.

Time Symmetry

99.5% to 100 kHz, 99.0% to 1 MHz.

Jitter

0.025% cycle to cycle.

VERTICAL PRECISION

Frequency Response

0.1 dB to 100 kHz, 0.5 dB to 1 MHz.

Stability

0.05% for 10 minutes; 0.25% for 24 hours.

PURITY

Sine Wave Distortion

0.5% for 0.0015 Hz to 10 kHz.
1.0% for 10 kHz to 100 kHz.
3.0% for 100 kHz to 1 MHz.

Triangle and Ramp Linearity

99% to 100 kHz, 95% to 1 MHz.

Square Wave Rise and Fall Time

Fixed Outputs: Less than 15 ns.
Variable Output: Less than 100 ns.

Total Aberrations

Less than 5% into 50Ω.

ENVIRONMENTAL

All specifications apply for 25°C ±5°C.

MECHANICAL

Dimensions

7¾ in./19.7 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

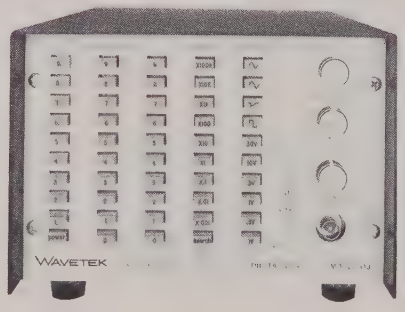
9 lb/4.1 kg net, 14 lb/6.4 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 10 watts. Ni-cad batteries and built-in charger furnished with 112B.

ORDER INFORMATION
(FOB San Diego)

Model 112	**$795**
Model 112B	**$945**



Model 113

This model offers push button control of frequency, function, and amplitude, plus voltage control of frequency by external input — either dc programming or wide band ac frequency modulation. Amplitude is controlled by a precision 50 ohm attenuator that provides 10 dB steps from 0.1 volt to 10 volts peak-to-peak. The push button control offers excellent repeatability and simplicity for production line operations. In search mode frequency, push buttons are replaced by a 1- turn control to make frequency tuning possible. DC offset is also provided.

VERSATILITY

Waveforms

Sine, square, triangle, ramp, and sync pulse.

Frequency Range

0.001 Hz to 1 MHz in 9 ranges.

Simultaneous Outputs

5 (4 fixed, 1 variable amplitude).

Output Level

Variable: 30 V p-p max into 600Ω; 10 V p-p max into 50Ω (113B:5 V p-p into open circuit).

Fixed: 5 V p-p into open circuit; 2.5 V p-p into 50Ω.

DC offset: ±5 V p-p into open circuit (7.5 V peak limit).

Output Impedance

50Ω (600Ω available)

VCG — Voltage Controlled Generator

Frequency may be dc-programmed or ac-modulated (FM) over 100:1 range.

Linearity: 0.1% (10% to 100% of full scale).

Bandwidth: 100 kHz.

HORIZONTAL PRECISION

Push Button Accuracy

±1% of setting for 0.001 Hz to 100 kHz.
±2% of setting for 100 kHz to 1 MHz.

Vernier Accuracy

One turn for 1% change of full scale.

Time Symmetry

99.5% to 100 kHz, 99.0% to 1 MHz.

Jitter

0.025% cycle to cycle.

VERTICAL PRECISION

Accuracy

±1% for 0.1 V p-p to 10 V p-p into 50Ω with vernier in CAL.

Frequency Response

0.1 dB to 100 kHz, 0.5 dB to 1 MHz.

Stability

0.05% for 10 minutes; 0.25% for 24 hours.

PURITY

Sine Wave Distortion

0.5% for 0.001 Hz to 10 kHz.
1.0% for 10 kHz to 100 kHz.
3.0% for 100 kHz to 1 MHz.

Triangle and Ramp Linearity

99% to 100 kHz, 95% to 1 MHz.

Square Wave Rise and Fall Time

Fixed Outputs: Less than 15 ns.
Variable Output: Less than 100 ns.

Total Aberrations

Less than 5% into 50Ω.

ENVIRONMENTAL

All specifications apply for 25°C ±5°C.

MECHANICAL

Dimensions

7¾ in./19.7 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

9 lb/4.1 kg net, 14 lb/6.4 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 10 watts.

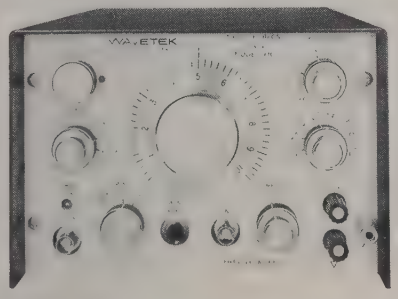
ORDER INFORMATION
(FOB San Diego)

Model 113	**$895**

MODELS 114/116 FUNCTION GENERATORS

Model 114

This model is two independent generators in a single unit. One is a precision source of sine, square, and triangle waveforms. The other is a ramp generator for sweeping the frequency of the first. Both may be operated continuously or triggered with independent frequency control. In the triggered mode, the start/stop point may be varied 360°. Sine² pulses are available as well as haversine. The sweep and hold mode allows static setting of both start and stop frequencies. The 114 operates in gated (tone burst), continuous, sweep, and triggered sweep modes.



Model 116

This unit produces sine, square, triangle, and ramp waveforms with triggered, gated, and phase lock operation. A specialized tone burst is also provided which gives discrete bursts of cycles from 2 to 256 in binary increments. In the triggered mode, the start/stop point may be varied 360°. Sine² and haversine waveforms are available. Phase lock operation converts the generator to a slave unit where the frequency is locked to an external frequency input, such as a crystal or master system clock; the relative phase of the two sources is controllable over 360°.

Note: The following specifications apply to both the 114 and 116. "B" denotes the battery versions.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, ramp ◿, sync pulse.

Frequency Range

0.0015 Hz to 1 MHz in 16 overlapping ranges.

Simultaneous Outputs

9 (8 fixed, 1 variable amplitude).

Output Level

Variable: 30 V p-p max into 600Ω; 10 V p-p max into 50Ω (114B and 116B: 5 V p-p into open circuit).

Fixed: 5 V p-p into open circuit; 2.5 V p-p into 50Ω.

Output Impedance

Variable Output: 50Ω (600Ω available) (114B and 116B: 600Ω).

Fixed Output: 50Ω.

VCG — Voltage Controlled Generator

Frequency may be dc-programmed (FSK) or ac-modulated (FM) over 20:1 range.

Linearity: 0.1% (10% to 100% of full scale).

Bandwidth: 100 kHz.

Operating Modes

114 Continuous, triggered, gated, continuous sweep, triggered sweep, and sweep and hold

116 Continuous, triggered, gated, binary tone burst, and phase lock

HORIZONTAL PRECISION

Dial Accuracy

±1% of full scale for 0.0015 Hz to 100 kHz

±2% of full scale for 100 kHz to 1 MHz

Vernier Accuracy

One turn for 1% change of full scale

Time Symmetry

99.5% for 0.0015 Hz to 100 kHz

99.0% for 100 kHz to 1 MHz

Jitter

0.025% cycle to cycle

VERTICAL PRECISION

Frequency Response

0.1 dB for 0.0015 Hz to 100 kHz.

0.5 dB for 100 kHz to 1 MHz.

Stability

0.05% for 10 minutes; 0.25% for 24 hours.

PURITY

Sine Wave Distortion

0.5% for 0.0015 Hz to 10 kHz.

1.0% for 10 kHz to 100 kHz.

2.0% for 100 kHz to 600 kHz.

3.0% for 600 kHz to 1 MHz.

Triangle and Ramp Linearity

99% for 0.0015 Hz to 100 kHz.

95% for 100 kHz to 1 MHz.

Square Wave Rise and Fall Time

Fixed Outputs: Less than 15 ns.

Variable Output: Less than 100 ns.

Total Aberrations

Less than 5% into 50Ω.

ENVIRONMENTAL

All specifications apply for 25°C ±5°C.

MECHANICAL

Dimensions

7¾ in./19.7 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

9 lb/4.1 kg net, 14 lb/6.4 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 10 watts. Ni-cad batteries and built-in charger furnished with 114B and 116B.

ORDER INFORMATION

(FOB San Diego)

Model 114	**$945**
Model 114B	**$1095**
Model 116	**$945**
Model 116B	**$1095**

SERIES 130 FUNCTION GENERATORS

This series of seven generators offers high purity sources of sine, square, and triangle waveforms; each model (except the Model 133 low frequency generator) has the frequency range of 0.2 Hz to 2 MHz. The Model 133 has a usable frequency range extending down from 200 kHz to an extremely slow 2 μHz— a 135 hour period.

The first of the series, the Model 130, offers function generator versatility for the low price of an oscillator. With variable frequency and signal attenuation this instrument has many applications in ultrasonics, audio, and video fields.

Where voltage control of generator frequency (VCG) is necessary, any model of the 130 series can supply it except the Model 130.

The ability to test with repeatable noise can be realized with the Model 132, the only Wavetek function generator featuring pseudo-random noise, both digital and analog, for noise or calibrated signal-with-noise. The pseudo-random sequence length, the clock rates and the bandwidth are selectable.

In addition to its low frequency capability, the Model 133 offers precision waveform control. Waveform start / stop point may also be controlled.

Internal sweep generators are featured in both the 134 and 135. The 135 offers the popular logarithmic as well as linear sweep.

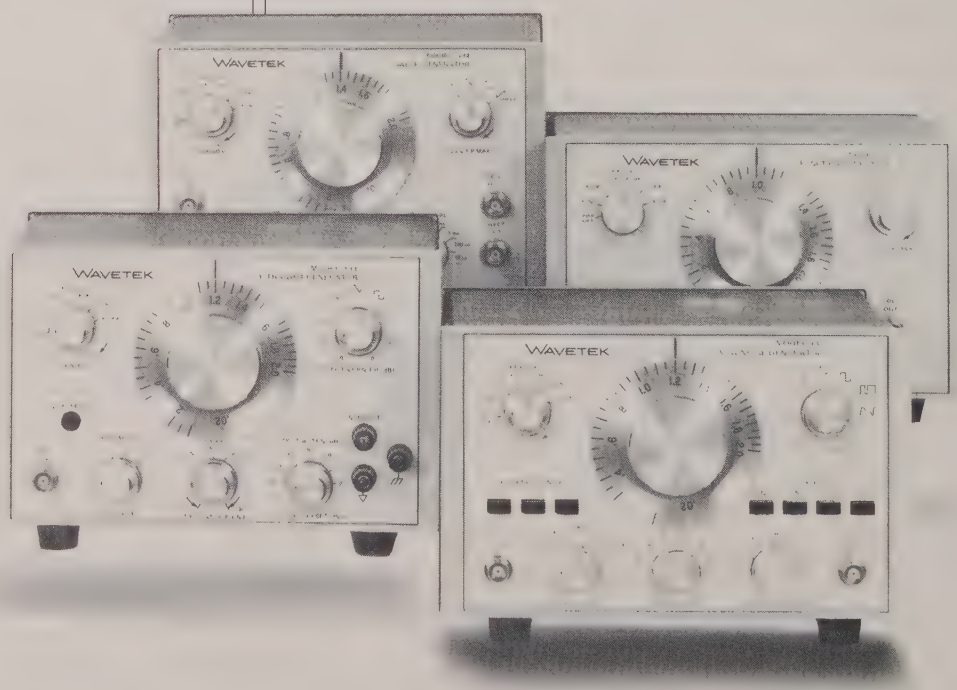
The Model 136 features continuously variable amplitude modulation as well as frequency modulation.

These and other features of the 130 series can be easily compared on the selection guide and examined in detail in the following specification pages.

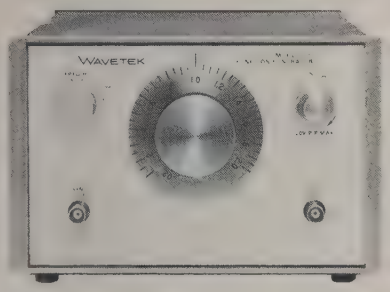
SELECTION GUIDE

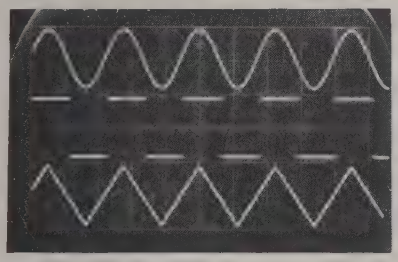
Features	Model 130	131A	132	133	134	135	136
Basic Waveforms ∿ , ⎍ , ⩘	X	X	X	X	X	X	X
Variable Amplitude Sweep Out	—	—	—	—	—	X	—
Fixed Amplitude Sweep Output	—	—	—	—	X	—	—
Fixed Amplitude Sine Output	—	—	—	—	—	—	X
Analog/Digital Noise	—	—	X	—	—	—	—
Frequency:							
0.2 Hz to 2 MHz	X	X	X	—	X	X	X
2 μHz to 200 kHz	—	—	—	X	—	—	—
40 dB Variable Attenuator	X	—	—	—	X	X	—
60 dB Attenuator in 10 dB Steps	—	X	X	X	—	—	X
GCV Output and Log Sweep	—	—	—	—	—	X	—
Sync Output	X	X	X	X	X	X	X
50/600Ω Balance Output	—	X	—	—	—	—	—
DC Offset	X	X	X	X	X	X	X
VCG (FM)	—	X	X	X	X	X	X
VCA (AM)	—	—	—	—	—	—	X
External Triggering and Gating	—	—	—	X	X	X	—
Adjustable Start/Stop Points	—	—	—	X	—	—	—
Internal Sweep	—	—	—	—	X	X	—
Internal Tone Burst	—	—	—	—	X	X	—

Note: All instruments are available with 600Ω output impedance (request at time of order.)



MODEL 130 FUNCTION GENERATOR





The Wavetek Model 130 is the first general-purpose laboratory test instrument that offers true function generator versatility for the low price of an oscillator. This attractive, all-solid-state unit is a high-purity source of sine, square, and triangle waveforms which can be generated over a frequency range of 0.2 Hz to 2 MHz. The outputs are selectable and variable from a 50Ω source with an auxiliary sync output for scope or system timing. The instrument is ideal for ultrasonic, audio, and video applications — from trouble-shooting to exotic IC design. Rugged construction, compact size, and precision operating characteristics make the Model 130 a portable laboratory of test signals in one economical package.

VERSATILITY

Waveforms

Sine ∿, square ⊓, and triangle △.

Dynamic Frequency Range

0.2 Hz to 2 MHz.

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Outputs

Sine ∿, square ⊓, and triangle △ selectable; amplitude variable over 40 dB; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output.

HORIZONTAL PRECISION

Dial Accuracy

±2% of full scale, 1 Hz to 2 MHz.

Time Symmetry

±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB from 0.2 Hz to 200 kHz.
0.5 dB from 0.2 Hz to 2 MHz.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

PURITY

Sine Wave Distortion

Less than:
0.5% on X 10, X 100, X 1K, X 10K ranges.
1.0% on X 100K range.
2.0% on X 1M range.

Square Wave Rise and Fall Time

Less than 50 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

7 lb/3.2 kg net, 10 lb/4.5 kg shipping.

Power

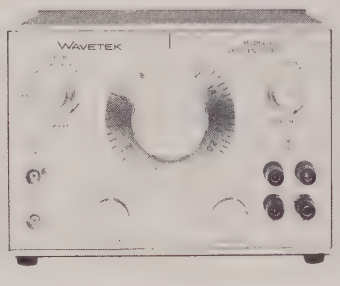
10 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 15 watts.

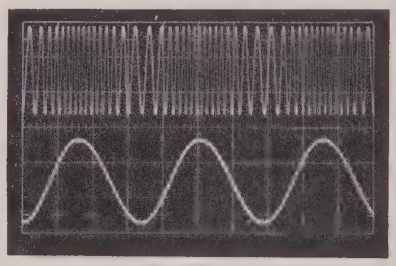
Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 130 — $295 (FOB San Diego)

MODEL 131A VOLTAGE CONTROLLED GENERATOR





The Model 131A Voltage Controlled Generator (VCG) is a precision source of sine, square, and triangle waves that may be externally voltage controlled. The frequency may be modulated or dc-programmed; the instantaneous resultant frequency is the sum of the dial setting and the externally applied voltage. A positive voltage increases frequency and a negative voltage decreases frequency. The output waveforms (from 0.2 Hz to 2 MHz) are selectable and an auxiliary sync output is available for scope or system timing. The Model 131A can be swept over a 1000:1 ratio and is designed so that the audio range of 20 Hz to 20 kHz may be covered in a single sweep without changing ranges. The signal output impedance can be selected at 50Ω floating or 600Ω balanced. For increased versatility a 60 dB precision step attenuator gives full control over output signal level from 1 mV peak to peak to 20 V peak to peak. Rugged construction, compact size, and precision operating characteristics make the Model 131A a portable laboratory of test signals. Actually, it is an oscillator, square wave generator, FM modulator, frequency shift keyer, and sweep generator, all in one economical package.

VERSATILITY

Waveforms

Sine, square, and triangle.

Dynamic Frequency Range

0.2 Hz to 2 MHz (50Ω OUT).
0.2 Hz to 20 kHz (600Ω BAL OUT).
Usable to 2 MHz (600Ω BAL OUT).

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Outputs

Sine, square, and triangle selectable; with 60 dB step attenuator in 10 dB steps and overlapping vernier control; 50Ω output impedance; 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; 600Ω output impedance balanced with center tap; 20 V p-p into open circuit and 10 V p-p into 600Ω balanced load from 600Ω balanced source impedance; short circuit current is ±100 mA.

Note: When 600Ω BAL OUT is used as a balanced output, the instrument signal common may not be tied to any external signal common unless the common is completely floating and no dc path exists to the 131A common (BNC shell).

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load or 600Ω balanced load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output. DC offset voltage as well as waveform is proportionally attenuated by the step attenuator.

VCG — Voltage Controlled Generator

Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation of the output frequency. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs. The instantaneous frequency is the result of the sum of the dial setting and the externally applied voltage.

HORIZONTAL PRECISION

Dial Accuracy

±2% of full scale, 1 Hz to 2 MHz.

Frequency Vernier

One turn for approximately 1% of full scale change.

Time Symmetry

±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB from 0.2 Hz to 200 kHz.
0.5 dB from 0.2 Hz to 2 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

PURITY

Sine Wave Distortion

Less than:
0.5% on X 10, X 100, X 1K, X 10K ranges.
1.0% on X 100K range.
2.0% on X 1M range.

Square Wave Rise and Fall Time

Less than 50 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

8 lb/3.6 kg net, 11 lb/4.99 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 15 watts.

Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 131A — $395 (FOB San Diego)

MODEL 132 VCG/NOISE GENERATOR

The Wavetek Model 132 VCG/Noise Generator is a source of pseudo-random analog and digital noise, as well as a precision sine, square, and triangle waveform generator. The signal and noise outputs can be used independently or they can be used together to provide signals with calibrated signal-to-noise ratios.

The noise function provides a digital pseudo-random sequence with selectable sequence length and variable clock rates up to 1.6 MHz. In addition, an analog noise output can be selected which provides analog noise with continuously variable bandwidth up to 100 kHz. The analog noise can be combined with the sine, square, or triangle waveform amplitude in the signal-to-noise or noise-to-signal mode. The S/N and N/S ratios can both be varied over a 60 dB range with calibrated front panel control. In the FM mode, the noise is used to provide a variable random jitter to the signal frequency.

The sine, square, and triangle waveforms may be controlled by an external voltage (VCG) — either dc-programmed or wide band ac-modulated. The instantaneous resultant frequency is the sum of the dial setting and the externally applied voltages; positive voltage increases frequency and negative voltage decreases frequency.

The Model 132 provides an oscillator, square wave generator, sweep generator, FM modulator, wide band noise generator, and pseudo-random sequence generator in one well designed portable unit.

VERSATILITY

Waveforms

Sine ∿, square ⊓, and triangle △ waveforms; analog noise ⌇, or digital noise ⎍

Dynamic Frequency Range

0.2 Hz to 2 MHz.

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Function Outputs

Sine ∿, square ⊓, and triangle △ selectable; with 60 dB step attenuator in 10 dB steps and overlapping vernier control; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output.

VCG — Voltage Controlled Generator

Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs. The instantaneous frequency is the result of the sum of the dial setting and the externally applied voltage.

OPERATIONAL MODES

FUNC — Function — Provides the selected waveform at the main output.

S/N — Signal-to-Noise — Adds noise to a selected signal of constant amplitude. The signal-to-noise ratio is variable from 0 to −50 dB.

N/S — Noise-to-Signal — Adds a selected signal to a constant amplitude noise. The noise-to-signal ratio is variable from 0 to −50 dB.

FM — Frequency Modulation — Provides random modulation of the frequency of the generator. The S/N — N/S (dB) ratio control also controls the amount of frequency deviation.

Note: When noise is added to the signal output, specifications apply up to 200 kHz and the square wave rise time is derated by a factor of 10. In the clock range of 1.6 MHz, the maximum calibrated signal-to-noise ratio is 30 dB.

HORIZONTAL PRECISION

Dial Accuracy

±2% of full scale, 1 Hz to 2 MHz.

Frequency Vernier

One turn for approximately 1% of full scale change.

Time Symmetry

±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB from 0.2 Hz to 200 kHz.
0.5 dB from 0.2 Hz to 2 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude frequency, and dc offset.

PURITY

Sine Wave Distortion

Less than:
0.5% on X 10, X 100, X 1K, X 10K ranges.
1.0% on X 100K range.
2.0% on X 1M range.

Square Wave Rise and Fall Time

Less than 50 ns.

Noise Outputs

Pseudo-random analog or digital noise with a maximum of 20 V p-p excursion (open circuit) with 60 dB step attenuator in 10 dB steps and overlapping calibrated vernier.

Noise Sync Output

Rear panel output provides the clock frequency output and an output once each time the sequence repeats.

Sequence Lengths

Push buttons on the front panel provide a sequence length of $2^{10}-1$, $2^{15}-1$, or $2^{20}-1$.

Noise Clock Frequency

Continuously variable from 160 Hz to 1.6 MHz in five ranges.

Clock Frequency Range	Analog Noise Bandwidth
160 Hz	10 Hz
1.6 kHz	100 Hz
16 kHz	1 kHz
160 kHz	10 kHz
1.6 MHz	100 kHz

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

8 lb/3.6 kg net, 12 lb/5.45 kg shipping.

Power

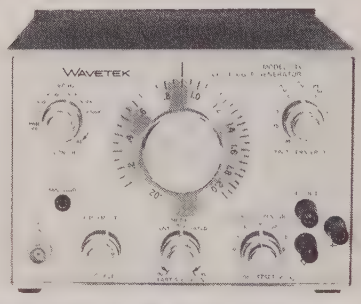
105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 30 watts.

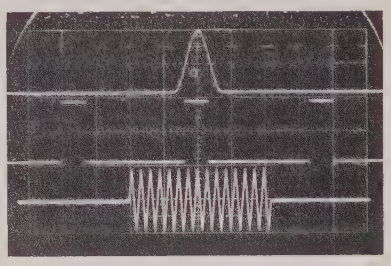
Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 132 — $795 (FOB San Diego)

MODEL 133 LF TRIGGER GENERATOR





The Model 133 Low Frequency/Trigger Generator is a precision sine,square, and triangle waveform source designed specifically for critical trigger applications and for ultra low frequency use. The usable frequency range of the instrument extends from 0.000002 Hz, or 138 hours per cycle, to 200 kHz.

In the Trigger mode of operation, the Model 133 features an extremely stable base line which is essentially constant with changing frequency. The instrument will trigger with the application of low voltage to the trigger, but has a high immunity to spurious triggering due to line voltage transients. Triggering and gating can be accomplished manually or externally.

In addition, the generator also features VCG, which allows the frequency to be programmed by a dc voltage, or modulated by an ac signal; a 60 dB step attenuator for precision control of signal level; dc offset capability; and ±90° control of the start/stop point of the signal waveform.

VERSATILITY

Waveforms

Sine, square, and triangle.

Dynamic Frequency Range

0.000002 Hz (or 2 μHz) to 200 kHz.

Calibrated range — 100 μHz to 200 kHz.

Ranges

X 0.001*	0.00002 Hz to 0.002 Hz
X 0.01*	0.0002 Hz to 0.02 Hz
X 0.1*	0.002 Hz to 0.2 Hz
X 1*	0.02 Hz to 2 Hz
X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz

*Denotes auxiliary multiplier ranges for ultra low frequency operation.

Outputs

Sine, square, and triangle selectable; output is controlled with 60 dB step attenuator in 10 dB steps and overlapping vernier control; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance. Output located on rear panel.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load) controlled from front panel; peak amplitude limited by the dynamic range of the amplifier output. DC offset and output waveform attenuated proportionately by the 60 dB output attenuator.

Trigger

External trigger input is located on the rear panel and input impedance is 10 kΩ. Manual trigger is also provided. Manual switch or external voltage of +1 V minimum peak will generate one cycle of a selected waveform. Up to 100 volts may be applied without damage to the input circuitry. The external trigger level and the waveform start/stop point are adjustable by front panel controls.

VCG — Voltage Controlled Generator

Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs. The instantaneous frequency is the result of the sum of the dial setting and the externally applied voltage.

OPERATIONAL MODES

CONT — Continuous — Operates as a standard VCG. Frequency determined by dial, vernier, and range settings in parallel with VCG input.

TRIG — Triggered — One complete cycle is generated by applying a pulse to the trigger input, or by operating manual switch.

GATED — Same as triggered mode, except that cycles continue for the duration of the input gate, or as long as the manual trigger switch is held closed.

HORIZONTAL PRECISION

Dial Accuracy

±2% of full scale on X 1 through X 100K ranges.

±(2% of setting +2% of full scale on X 0.001, X 0.01, and X 0.1 ranges.

Electronic Frequency Vernier

One turn for approximately 1% of full scale change.

Time Symmetry

±1% for X 1 to X 100K range.

±3% for X 0.001 to X 0.1 range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:

0.1 dB from 0.00002 Hz to 20 kHz.

0.2 dB from 0.00002 Hz to 200 kHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.

Long term: ±0.25% for 24 hours.

Percentages apply to amplitude, frequency, and dc offset.

Start/Stop Point Variation

Base line voltage varies less than ±0.1% of step attenuator range maximum as frequency is varied from 0.2 to 2 on the dial.

PURITY

Sine Wave Distortion

Less than:

3.0% on X 0.001, X 0.01, X 0.1 ranges.

0.5% on X 1, X 10, X 100, X 1K, X 10K ranges.

1.0% on X 100K range.

Square Wave Rise and Fall Time

Less than 50 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

8 lb/3.6 kg net, 11 lb/4.99 kg shipping.

Power

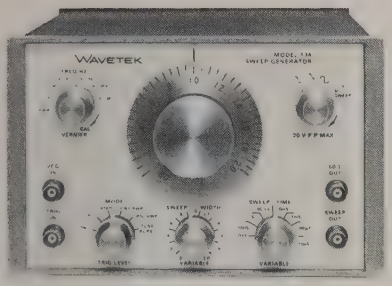
105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 20 watts.

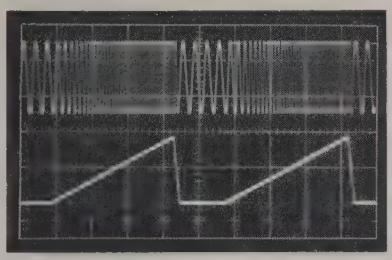
Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 133 — $495 (FOB San Diego)

MODEL 134 SWEEP/TRIGGER VCG





The Model 134 Sweep Generator is actually two independent generators in one compact unit. The first generator is a precision voltage controlled generator with sine, square, and triangle waveform outputs. The second generator is a triggered ramp and sawtooth generator which supplies the voltage for sweeping the frequency of the first. Both generators may be operated independently in the continuous or triggered mode with independent frequency control.

In addition to internal sweep, terminals are provided for external voltage control of frequency (VCG)—either dc-programmed or wide band ac-modulation. The instantaneous resultant frequency is the sum of the dial setting and the externally applied voltages; positive voltage increases frequency and negative voltage decreases frequency. The Model 134 can be used in continuous, triggered, gated, continuous with sweep, triggered with sweep, or tone burst mode. The output waveforms, from 0.2 Hz to 2 MHz, are selectable and variable from a 50Ω source. The sweep output (0 to +5 volts) is proportional to the frequency of the main generator when in the sweep mode. The instrument may be swept over a 1000:1 ratio and is so designed that the entire audio band from 20 Hz to 20 kHz may be covered without range change.

While the Model 134 is designated a sweep/trigger VCG, it also is a portable oscillator, square wave generator, FM modulator, frequency shift keyer, and sweep and tone burst generator.

VERSATILITY

Waveforms
Sine ∿, square ⊓, triangle △, and sweep ⟋.

Dynamic Frequency Range
0.2 Hz to 2 MHz.

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Outputs
Sine ∿, square ⊓, triangle △, and sweep ⟋ selectable; amplitude variable over 40 dB; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

Sweep Output
0 to +5 V sawtooth waveform into open circuit, 600Ω source impedance.

Sync Output
Greater than 1 V p-p square wave into open circuit, 600Ω source impedance.

DC Offset
±5 V offset (±2.5 V offset into 50Ω load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output.

VCG — Voltage Controlled Generator
Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs.

OPERATIONAL MODES

Continuous
Operates as a standard VCG. Frequency determined by dial/vernier/range settings in parallel with VCG input.

Triggered
One complete cycle is generated by applying a pulse to the trigger input.

Gated
Same as triggered except that cycles continue for the duration of input gate.

Continuous Sweep
The main generator is frequency modulated by the sweep generator. When swept, the main generator frequency, set by the dial and range settings, rises to the frequency selected by the sweep-width control. Sweep rate is set by front panel control.

Triggered Sweep
Same as continuous sweep mode except one complete sweep cycle is generated for each input trigger pulse. Main generator continues to oscillate between sweep cycles.

Tone Burst
Main generator is gated by the sweep output (internally connected). The tone burst rate, frequency, and length can be independently controlled.

Trigger Input
1 V peak into 10 kΩ impedance dc coupled to 200 kHz, proportionally greater at higher frequencies.

Sweep Time
10 μs to 100 s.

Sweep Width
Up to 1000:1 with calibrated control.

HORIZONTAL PRECISION

Dial Accuracy
±2% of full scale, 1 Hz to 2 MHz.

Electronic Frequency Vernier
One turn for approximately 1% of full scale change.

Time Symmetry
±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response
Amplitude change with frequency less than:
0.1 dB from 0.2 Hz to 200 kHz.
0.5 dB from 0.2 Hz to 2 MHz.

Stability
Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

PURITY

Sine Wave Distortion
Less than:
0.5% on X 10, X 100, X 1K, X 10K ranges.
1.0% on X 100K range.
2.0% on X 1M range.

Square Wave Rise and Fall Time
Less than 50 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions
8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight
8 lb/3.6 kg net, 11 lb/4.99 kg shipping.

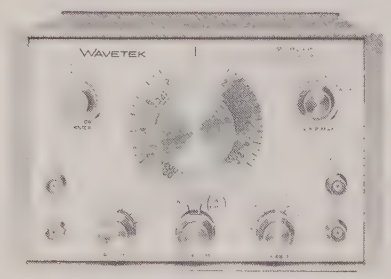
Power
105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 20 watts.

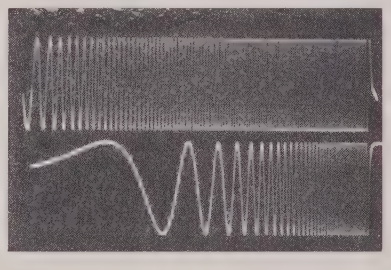
Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 134 — $495 (FOB San Diego)

MODEL 135 LIN/LOG SWEEP GENERATOR





The Model 135 LIN/LOG Sweep Generator produces sine, square, and triangle waveforms which may automatically be swept in frequency up to a 1000:1 ratio. The Model 135 is actually two independent generators in one compact unit. The first generator is a precision voltage controlled generator with sine, square, and triangle waveform outputs. The second generator is a triggered ramp and sawtooth generator which supplies the voltage for sweeping the frequency of the first in either a linear or logarithmic mode. Both generators may be operated independently.

Terminals are provided for external voltage control of frequency (VCG) — either dc-programmed or wide band ac-modulation. The instrument may be swept over the entire audio band from 20 Hz to 20 kHz without range change.

This versatile instrument also features a voltage output (GCV) that is proportional to the instantaneous frequency of the generator. This output can be used as the calibrated horizontal drive for an oscilloscope or an X-Y recorder.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, and sweep ⟋.

Dynamic Frequency Range

0.2 Hz to 2 MHz.

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Outputs

Sine ∿, square ⊓, triangle △, and sweep ⟋ selectable; amplitude variable over 40 dB; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

GCV Output

0 to 5 V (maximum limits) proportional to the frequency of the main generator. Output impedance 600Ω.

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output.

VCG — Voltage Controlled Generator

Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs. The instantaneous frequency is the result of the sum of the dial setting and the externally applied voltage.

OPERATIONAL MODES

Continuous

Operates as a standard VCG. Frequency determined by dial/vernier/range settings in parallel with VCG input.

Triggered

One complete cycle is generated by applying a pulse to the trigger input.

Gated

Same as triggered except that cycles continue for the duration of input gate.

Continuous Sweep

The main generator is frequency modulated by the sweep generator. When swept, the main generator frequency rises from the frequency set by the dial and range settings to a frequency selected by the sweep-width control. Sweep rate and sweep function (LIN or LOG) are selected by front panel controls.

Triggered Sweep

Same as continuous sweep mode except one complete sweep cycle is generated for each input trigger pulse. Main generator continues to oscillate between sweep cycles.

Tone Burst

Main generator is gated by the sweep output (internally connected). The tone burst rate, frequency, and length can be independently controlled.

Trigger Input

1 V peak into 10 kΩ impedance dc coupled to 200 kHz proportionally greater at higher frequencies.

Sweep Time

10 μs to 100 s.

Sweep Width

Up to 1000:1 with front panel control.

HORIZONTAL PRECISION

Dial Accuracy

For LIN FREQ, ±2% of full scale, 1 Hz to 2 MHz.

For (LOG FREQ), approximate dial calibrations are shown in parentheses.

Electronic Frequency Vernier

For LIN FREQ, one turn for approximately 1% control of full scale. For (LOG FREQ), one turn for approximately 1% control of the output frequency.

Time Symmetry

±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:

0.1 dB from 0.2 Hz to 200 kHz.

0.5 dB from 0.2 Hz to 2 MHz.

Stability

Short term: ±0.05% for 10 minutes.

Long term: ±0.25% for 24 hours.

Percentages apply to amplitude, frequency, and dc offset.

PURITY

Sine Wave Distortion

Less than:

0.5% on X10, X100, X1K, X10K ranges.

1.0% on X100K range.

2.0% on X1M range.

Square Wave Rise and Fall Time

Less than 50 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

9 lb/4.1 kg net, 13 lb/5.9 kg shipping.

Power

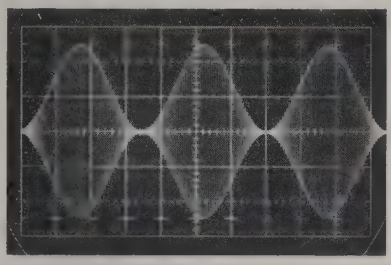
105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 25 watts (continuous).

Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 135 — $695 (FOB San Diego)

MODEL 136 VCG/VCA GENERATOR



The Model 136 VCG/VCA Generator is a precision source of sine, square, and triangle waveforms that may be externally voltage controlled in amplitude (VCA) and in frequency (VCG). The amplitude level can be continuously controlled from dc step programming through 100% amplitude modulation to suppressed carrier AM. The frequency can be continuously controlled either by dc programming or by wide band modulation up to a 1000:1 ratio.

The Model 136 is actually an oscillator, square wave generator, triangle wave generator, and an AM-FM generator in one rugged, compact package. The versatility and precision operating characteristics of the instrument make it a portable laboratory of test signals that can be used as a CW signal generator, tone burst generator, frequency shift keyer, sweep generator, and a dc-programmable generator.

VERSATILITY

Waveforms

Sine ∿ , square ⊓ , and triangle △

Dynamic Frequency Range

0.2 Hz to 2 MHz.

Note: The fixed (unmodulated) sine waveform can be used to self-modulate the generator and extend the frequency range to 4 MHz.

Ranges

X 10	0.2 Hz to 20 Hz
X 100	2 Hz to 200 Hz
X 1K	20 Hz to 2 kHz
X 10K	200 Hz to 20 kHz
X 100K	2 kHz to 200 kHz
X 1M	20 kHz to 2 MHz

Outputs

Sine ∿ , square ⊓ , and triangle △ selectable; with 60 dB step attenuator in 10 dB steps and overlapping vernier control; 50Ω output impedance (600Ω available); 20 V p-p into open circuit and 10 V p-p into 50Ω load from 50Ω source impedance; short circuit current is ±100 mA.

Fixed Sine Output

2.5 V p-p (fixed) into an open circuit. This output is unaffected by any amplitude modulation signal.

Sync Output

Greater than 1 V p-p square wave into open circuit at 600Ω output impedance.

DC Offset

±5 V offset (±2.5 V offset into 50Ω load) controlled from rear panel; peak amplitude limited by the dynamic range of the amplifier output.

VCA — Voltage Control of Amplitude

Amplitude of the generator may be dc-programmed or ac-modulated by a 0 to 5 volt signal. The voltage control circuitry is bipolar and operates linearly over a 40 dB range. The VCA bandwidth is 4 MHz. The output amplitude at any time is determined by the output attenuator, the step attenuator, and any externally applied voltage.

VCG — Voltage Controlled Generator

Frequency of generator may be dc-programmed or ac-modulated by external 0 to 5 V signal. Voltage control circuitry is capable of 1000:1 deviation. The VCG amplifier has a 100 kHz bandwidth and a slew rate of 0.1 V/μs. The instantaneous frequency is the result of the sum of the dial setting and externally applied voltage.

HORIZONTAL PRECISION

Dial Accuracy

±2% of full scale, 1 Hz to 2 MHz.

Electronic Frequency Vernier

One turn for approximately 1% of full scale change.

Time Symmetry

±1% through X 100K range.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB from 0.2 Hz to 200 kHz.
0.5 dB from 0.2 Hz to 2 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

PURITY

Sine Wave Distortion

Less than:
0.5% on X10, X100, X1K, X10K ranges.
1.0% on X100K range.
2.0% on X1M range.

Square Wave Rise and Fall Time

Less than 100 ns.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. The generator will operate from 0°C to 55°C.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

8 lb/3.6 kg net, 12 lb/5.5 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 15 watts.

Note: Specifications apply for frequencies obtained when dial is between 0.1 and 2 and at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

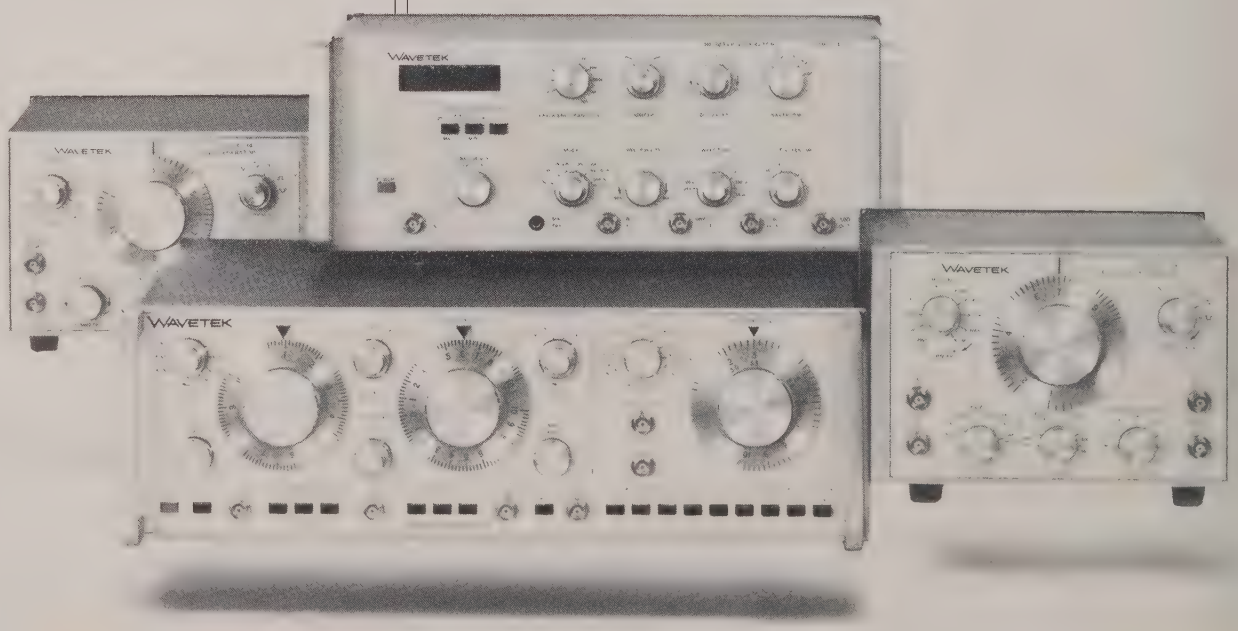
Model 136 — $595 (FOB San Diego)

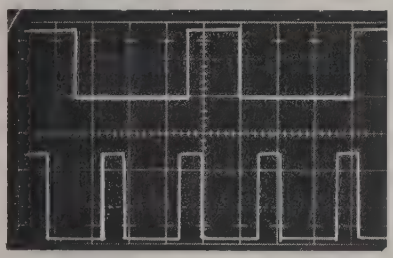
SERIES 140 VOLTAGE CONTROLLED GENERATORS

The 140 series of function generators provides a broad range of waveforms to 10 MHz. These instruments also generate a new dimension in waveform versatility — variable symmetry control. With this useful feature, the triangle wave can be modified to a ramp output with variable rise/fall ratios. The square duty cycle wave can be adjusted from a normal 50% duty cycle to a variable duty cycle with ratios of 1:19 to 19:1. The excellent control features for waveform, output level, frequency, and dc offset that are designed into the 140 series provide unprecedented versatility in laboratory signal sources.

SELECTION GUIDE

Features	Model 142	144	146	147
Basic Waveforms ∿ , ⊓ , ◺	X	X	X	X
Sawtooth ◿, ◺	X	X	X	X
Pulse ⊔, ⊓	X	X	X	X
Internal Sweep and Sweep Output ◿	—	X	X	X
180° Phase Shifted ∩ , ⊓ , ∧, ◺	—	—	X	—
DC Voltage Output	—	—	X	X
Adjustable Waveform Symmetry	X	X	X	X
Internal Sweep-and-Hold	—	X	—	X
Internal Tone Burst	—	X	X	X
VCG (FM)	X	X	X	X
VCA (AM)	—	—	X	—
Frequency Range: 0.0005 Hz to 10 MHz	X	X	X	X
Attenuation: 80 dB Stepped and Vernier	X	X	—	X
Amplitude Control and Vernier	—	—	X	—
Triggering and Gating	—	X	X	X
DC Offset	—	X	X	X
GCV Output (Voltage Proportional to Frequency)	—	X	X	X
LED Frequency and ± Peak Amplitude Display	—	—	—	X

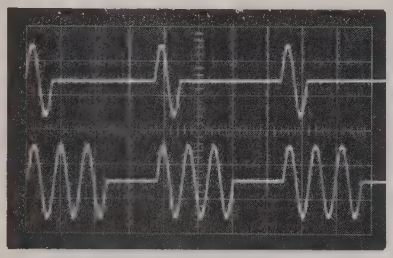


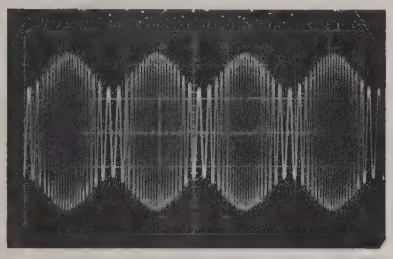


The Wavetek Model 142 is a voltage controlled generator which operates from 0.0005 Hz to 10 MHz. All waveforms, sine, square, triangle, and pulse can be adjusted in frequency, dc bias level, and symmetry. The symmetry control allows ramp and pulse outputs.

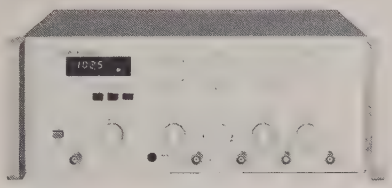
All outputs can be swept over a 1000:1 frequency range through Wavetek's exclusive VCG circuitry.

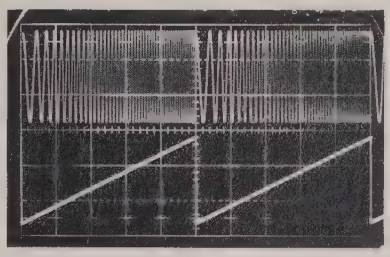
The Model 144 provides the same features, but has six selectable operating modes, continuous, triggered, gated, continuous sweep, triggered sweep and sweep and hold. The 144 actually is two complete generators, the function generator and an independent ramp generator. The ramp is used to sweep and trigger the main generator.





Wavetek's Model 146 Multifunction Generator has been designed to provide the most complete array of signal sources available in a single precision instrument. Sine, square, triangle, sawtooth, pulse, and dc waveforms can be accurately produced. Key to the wide range of applications of this instrument is the incorporation of two independent, triggerable generators in one integrated unit. This full-capability modulation generator offers the additional modes of frequency modulation, frequency sweep up to 1000:1 ratio, amplitude modulation through 100% to suppressed carrier modulation, and internal tone burst.





The Model 147 High Frequency Sweep Generator features digital convenience in a function generator. The frequency and amplitude of the generator can conveniently and accurately be displayed on the 3½ digit LED front panel readout. This capability allows the frequency and amplitude to be adjusted with precision when in the continuous mode or start/stop frequencies when in any of the sweep modes.

The 140 series generators provide performance and precision in these four easy to use instruments. The specifications following give full details of these versatile function generators.

MODEL 142 HF VCG GENERATOR

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, positive pulse ⎍, and negative pulse ⎎. Symmetry of all outputs continuously adjustable from 1:19 to 19:1. Varying triangle symmetry provides a sawtooth ◺ or ◿ output. Separate sync with variable symmetry.

Operating Frequency Range

0.0005 Hz to 10 MHz.

Ranges

X 0.001	0.0005 Hz to 0.01 Hz
X 0.01	0.005 Hz to 0.1 Hz
X 0.1	0.05 Hz to 1 Hz
X 1	0.1 Hz to 10 Hz
X 10	0.1 Hz to 100 Hz
X 100	1 Hz to 1 kHz
X 1K	10 Hz to 10 kHz
X 10K	100 Hz to 100 kHz
X 100K	1 kHz to 1 MHz
X 1M	10 kHz to 10 MHz

Note: When symmetry control is used, indicated frequency is divided by approximately 10.

Main Output

Sine, square, triangle, positive pulse, and negative pulse selectable. Maximum output 30 V p-p into open circuit (15 V peak pulse) with calibrated 15 V p-p into 50Ω load. Precision output attenuator calibrated in 10 dB steps to −60 dB with 20 dB vernier for overall attenuation of −80 dB. Output impedance is 50Ω. Short circuit current is 150 mA.

Sync Output

Amplitude greater than 4 V p-p into open circuit; 2 V p-p into 50Ω. Rise and fall times less than 20 ns. Square waveform for symmetrical outputs; rectangular waveform for pulse and ramp outputs. Sync pulse polarity opposite that of output square wave.

DC Offset

Controlled manually by front panel control or electronically by applying an external voltage. Adjustable range of ±10 Vdc into open circuit (±5 Vdc into 50Ω load) with peak output limited to ±15 Vdc into open circuit (±7.5 Vdc into 50Ω load). External offset sensitivity approximately −0.4 V/V with output connected to 50Ω load. DC offset and output waveform attenuated proportionately by 60 dB output attenuator.

VCG — VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Up to 1000:1 frequency change with external voltage input. Upper frequency is limited to maximum of selected range. Required external signal for full voltage control is 5 V with input impedance of 5 kΩ.

VCG Input Frequency

VCG Bandwidth: 100 kHz.
VCG Slew Rate: 2% of range per μs.

VCG Linearity

±0.2% for 10 Hz to 100 kHz.
±0.5% for 0.001 Hz to 1 MHz.
±1.0% for 1 MHz to 10 MHz.

HORIZONTAL PRECISION

Dial Accuracy for Symmetrical Waveforms

0.01 Hz to 1 MHz ±(1% of setting + 1% of full scale).
1 MHz to 10 MHz ±(2% of setting + 2% of full scale).

Vernier

Permits frequency adjustment of approximately 1% of range.

Time Symmetry

±0.5% for 10 Hz to 100 kHz.
±1.0% for 0.01 Hz to 500 kHz.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.2 dB to 1 MHz.
2.0 dB to 10 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All waveforms (except pulse) are symmetrical about ground within ±1% of maximum p-p amplitude.

PURITY

Sine Wave Distortion

Less than:
0.5% (typically 0.25%) for 10 Hz to 100 kHz.
1.0% for 100 kHz to 1 MHz.
All harmonics at least 30 dB down for 1 MHz to 10 MHz.

Triangle Linearity

Greater than 99% for 0.0005 Hz to 100 kHz.

Square Wave Rise and Fall Time

Less than 20 ns; limited to 500 V/μs (terminated into 50Ω load).

Total Aberrations

Less than 5%.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

8 lb/3.6 kg net, 12 lb/5.5 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 30 watts.

Note: Specifications apply for frequencies obtained when dial is between 1 and 10. Prices and specifications subject to change.

ORDER INFORMATION

Model 142 — $595 (FOB San Diego)

MODEL 144 HF SWEEP GENERATOR

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, positive pulse ⎍, and negative pulse ⎎. Symmetry of all outputs continuously adjustable from 1:19 to 19:1. Varying triangle symmetry produces sawtooth ◺ or ◿ output. Separate SWP/GCV and sync outputs with variable symmetry.

Operating Frequency Range

0.0005 Hz to 10 MHz in ten ranges:

X 0.001	0.0005 Hz to 0.01 Hz
X 0.01	0.005 Hz to 0.1 Hz
X 0.1	0.05 Hz to 1 Hz
X 1	0.1 Hz to 10 Hz
X 10	0.1 Hz to 100 Hz
X 100	1 Hz to 1 kHz
X 1K	10 Hz to 10 kHz
X 10K	100 Hz to 100 kHz
X 100K	1 kHz to 1 MHz
X 1M	10 kHz to 10 MHz

Note: When symmetry control is used, indicated frequency is divided by approximately 10.

Main Output

Sine, square, triangle, positive pulse, and negative pulse selectable. Maximum output 30 V p-p into open circuit (15 V peak pulse) with calibrated 10 V p-p into 50Ω load. Precision output attenuator calibrated in 10 dB steps to −60 dB with a 20 dB vernier for overall attenuation of −80 dB. Output impedance is 50Ω.

Sync Output

Amplitude greater than 4 V p-p into open circuit; 2 V p-p into 50Ω. Rise and fall times less than 20 ns. Square waveform for symmetrical outputs; rectangular waveform for pulse and ramp outputs. Polarity opposite that of output square wave.

DC Offset

Controlled manually by rear panel control. Adjustable range of ±10 Vdc into open circuit with peak signal and offset amplitude limited to ±15 Vdc into open circuit (±7.5 Vdc into 50Ω load). DC offset and output waveform attenuated proportionately by 60 dB output attenuator.

SWP/GCV Output

SWP output (0 to +5 V fixed) when in continuous, triggered, or gated mode. GCV output (0 to +5 V maximum) proportional to frequency control settings when in continuous sweep, triggered sweep, or sweep and hold mode.

VCG — VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Up to 1000:1 frequency change with external voltage input. Upper frequency limited to maximum of selected range. Required external signal for full voltage control is 5 V with input impedance of 5 kΩ.

VCG Input Frequency

VCG Bandwidth: 100 kHz.
VCG Slew Rate: 2% of range per μs.

VCG Linearity

±0.2% for 10 Hz to 100 kHz.
±0.5% for 0.005 Hz to 1 MHz.

OPERATIONAL MODES

Continuous

Operating as a standard VCG (voltage controlled generator), frequency determined by front panel control settings and VCG input signal.

Triggered

Same as continuous mode except that only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector.

Gated

Same as triggered mode except that output oscillations continue for duration of gating signal.

Continuous Sweep

Main generator is swept by internal sweep generator so that frequency is swept from a low frequency established by front panel controls to a high frequency determined by SWEEP WIDTH control setting. Sweep rate determined by SWEEP TIME controls. GCV (generator controlled voltage) output appears at SWP/GCV connector.

Triggered Sweep

Same as continuous sweep mode except that output is swept only once for each pulse applied to TRIG IN connector. During time between sweeps, main generator oscillates at the start frequency.

Sweep and Hold

Same as triggered sweep mode except that main generator oscillates at high frequency determined by SWEEP WIDTH control during time between sweeps.

Trigger Input

1 V peak into 10 kΩ, dc coupled.

Sweep Time

10 μs to 100 s.

Sweep Width

Up to 1000:1 with single turn control.

HORIZONTAL PRECISION

Dial Accuracy for Symmetrical Waveforms

0.01 Hz to 1 MHz ±(1% of setting +1% of full scale).
1 MHz to 10 MHz ±(2% of setting +2% of full scale).

Vernier

Permits frequency adjustment within approximately 1% of range.

Time Symmetry

±0.5% for 10 Hz to 100 kHz.
±1.0% for 0.01 Hz to 500 kHz.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.2 dB to 1 MHz.
2.0 dB to 10 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All waveforms (except pulse) symmetrical about ground within ±1% of maximum p-p amplitude.

PURITY

Sine Wave Distortion

Less than:
0.5% (typically 0.25%) for 10 Hz to 100 kHz.
1.0% for 100 kHz to 1 MHz.
All harmonics at least 30 dB down for 1 MHz to 10 MHz.

Triangle Linearity

Greater than 99% for 0.0005 Hz to 100 kHz.

Square Wave Rise and Fall Time

Less than 20 ns; limited to 500 V/μs (terminated into 50Ω load).

Total Aberrations

Less than 5%.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.3 cm high, 11½ in./29.2 cm deep.

Weight

9 lb/4.1 kg net, 13 lb/5.9 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 30 watts.

Note: Specifications apply for frequencies obtained when dial is between 1 and 10. Prices and specifications subject to change.

ORDER INFORMATION

Model 144 — $845 (FOB San Diego)

MODEL 146 MULTIFUNCTION GENERATOR

MAIN GENERATOR

VERSATILITY

Waveforms

Sine ∿ , square ⊓ , and triangle △ and dc voltage. Symmetry of all outputs continuously adjustable from 1:19 to 19:1, with rear panel control. Varying triangle symmetry produces sawtooth ◿ or ◺ output. Separate sync with variable symmetry. Waveform can be continuous, triggered, or gated.

Operating Frequency Range

0.0005 Hz to 10 MHz.

Ranges

X 0.001	0.0005 Hz to 0.01 Hz
X 0.01	0.005 Hz to 0.1 Hz
X 0.1	0.05 Hz to 1 Hz
X 1	0.1 Hz to 10 Hz
X 10	1 Hz to 100 Hz
X 100	10 Hz to 1 kHz
X 1K	100 Hz to 10 kHz
X 10K	1 kHz to 100 kHz
X 100K	10 kHz to 1 MHz
X 1M	100 kHz to 10 MHz

Note: When symmetry control is used, indicated frequency is divided by approximately 10.

Main Output

Sine, square, and triangle selectable. Maximum output 20 V p-p into open circuit; 10 V p-p into 50Ω load. Precision front dial controls the amplitude with high resolution and provides phase reversal of output. Precision output range multiplier has four decade steps. Output impedance is 50Ω. Short circuit current is 150 mA.

Sync Output

Amplitude greater than 4 V p-p into open circuit; 2 V p-p into 50Ω. Rise and fall times less than 50 ns. Square waveform for symmetrical outputs; rectangular waveform for nonsymmetrical outputs.

DC Offset

Controlled manually by front panel control. Adjustable range of ±10 Vdc into open circuit (±5 Vdc into 50Ω load) with peak output limited to ±15 Vdc into open circuit (±7.5 Vdc into 50Ω load). DC offset and output waveform attenuated proportionately by amplitude range multiplier.

VCG — VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Up to 1000:1 frequency change with external voltage input. Upper frequency limited to maximum of selected range. Minimum and maximum frequencies indicated by caliper pointers and center frequency indicated by frequency index when in internal sweep. Required external signal for full control is 5 V with input impedance of 5 kΩ. When FM switch is depressed, output of the auxiliary generator is connected to the VCG circuit and the FM LIMITS knob controls the amount of modulation.

VCG Input Frequency

VCG Bandwidth: 100 kHz.
VCG Slew Rate: 2% of range per μs.

VCG Linearity

±0.2% for 10 Hz to 100 kHz.
±0.5% for 0.001 Hz to 1 MHz.

HORIZONTAL PRECISION

Dial Accuracy for Symmetrical Waveforms

0.001 Hz to 1 MHz ±(1% of setting +1% of full scale).
1 MHz to 10 MHz ±(2% of setting +2% of full scale).

Vernier

Electronic vernier controls provided for precision frequency and amplitude adjustment.

Time Symmetry

±0.5% for 10 Hz to 100 kHz.
±1.0% for 0.001 Hz to 500 kHz.

VERTICAL PRECISION

Amplitude Readout Accuracy

0.001 Hz to 10 kHz ±(2% of setting +2% of full scale). Step attenuator accuracy of ±0.25 dB +1 mV.

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.2 dB to 1 MHz.
1.0 dB to 10 MHz.

VCA — Voltage Control of Amplitude

Full amplitude control with an external voltage input of ±5 V. The control is bipolar; i.e., amplitude can be controlled from maximum through null to range maximum at inverted phase. VCA input impedance is 10 kΩ. When AM switch is depressed, output of auxiliary generator is connected to VCA input. AM LIMITS control adjusts amount of AM modulation. Minimum and maximum amplitudes indicated by caliper pointers; mean amplitude indicated by amplitude index.

VCA Response

Bandwidth: 100 kHz.
Slew Rate: 2% of range per μs.

VCA Linearity

1% of full scale.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All waveforms symmetrical about ground within ±2% of maximum p-p amplitude (0 to 1 MHz).

PURITY

Sine Wave Distortion

Less than:
0.5% (typically 0.25%) for 10 Hz to 100 kHz.
1.0% for 0.001 Hz to 1 MHz.
All harmonics at least 25 dB down for 1 MHz to 10 MHz.

Triangle Linearity

Greater than 99% for 1 Hz to 100 kHz.

Square Wave Rise and Fall Time

Less than 50 ns (terminated into 50Ω load).

Total Aberrations

Less than 5%.

AUXILIARY GENERATOR

Waveforms

Selectable sine ∿ , square ⊓ , triangle △ , positive slope sawtooth ◿, and negative slope sawtooth ◺ outputs. Output level fixed 5 V p-p into open circuit. Approximately 2.5 V p-p into 600Ω (600Ω output impedance). Short circuit current approximately 4 mA peak. Rear panel AUX SYNC OUT connector provides approximately 5 V sync signal. Continuous, triggered, or gated operation.

Dynamic Frequency Range

0.004 Hz to 100 kHz (250 seconds per cycle to 10 μs per cycle) calibrated in frequency and time.

Operating Range

X 0.01 Hz	(◿ ◺ only) 0.004 Hz to 0.1 Hz
X 0.1 Hz	0.04 Hz to 1 Hz
X 1 Hz	0.4 Hz to 10 Hz
X 10 Hz	4 Hz to 100 Hz
X 100 Hz	40 Hz to 1 kHz
X 1 kHz	400 Hz to 10 kHz
X 10 kHz	(∿ ⊓ △ only) 4 kHz to 100 kHz

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

17¼ in./43.8 cm wide, 5¼ in./13.3 cm high, 17 in./43.2 cm deep.

Weight

14 lb/6.4 kg net, 23 lb/10.4 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 45 watts.

Note: Specifications apply for frequencies obtained when dial is between 1 and 10 on the Main and Auxiliary Generators. Main Generator output specifications apply at 10 V p-p into a 50 ohm load. Prices and specifications subject to change.

ORDER INFORMATION

Model 146 — $1495 (FOB San Diego)

MODEL 147 HF DIGITAL SWEEP GENERATOR

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, positive pulse ⎍, negative pulse ⎎, and dc voltage. Symmetry of all outputs continuously adjustable from 1:19 to 19:1. Varying triangle symmetry produces sawtooth ◺ or ◿ output. Separate SWP/GCV and sync outputs. Frequency, maximum peak signal, and minimum peak signal are indicated by 3½ digit readout.

Operating Frequency Range

0.0005 Hz to 10 MHz in ten ranges:

X 0.01	0.0005 Hz to 0.01 Hz
X 0.1	0.005 Hz to 0.1 Hz
X 1	0.05 Hz to 1 Hz
X 10	0.1 Hz to 10 Hz
X 100	1 Hz to 100 Hz
X 1K	10 Hz to 1 kHz
X 10K	100 Hz to 10 kHz
X 100K	1 kHz to 100 kHz
X 1M	10 kHz to 1 MHz
X 10M	100 kHz to 10 MHz

Note: When symmetry control is used, indicated frequency is divided by approximately 10.

Main Output

Selectable waveforms and dc voltage output. Maximum output 30 V p-p into open circuit; 15 V p-p into 50Ω load. Precision output attenuator calibrated in 20 dB steps to −60 dB with overlapping vernier for overall attenuation of −80 dB. Output impedance is 50Ω. Short circuit current is 150 mA.

Sync Output

TTL compatible output. Square waveform for symmetrical outputs; rectangular waveform for pulse and ramp outputs. Sync pulse polarity opposite that of output square wave.

DC Offset

Controlled manually by front panel control. Adjustable range of ±10 Vdc into open circuit (±5 Vdc into 50Ω load) with peak signal and offset amplitude limited to ±15 Vdc into open circuit (±7.5 Vdc into 50Ω load). Display will flash when peak amplitude plus offset exceeds generator limits. DC offset and output waveform attenuated proportionately by 60 dB output attenuator.

SWP/GCV Output

SWP output (0 to nominal +5 V sawtooth) when in continuous, triggered, or gated mode. GCV (generator controlled voltage) output proportional to instantaneous frequency output when in any sweep mode.

VCG — VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Up to 1000:1 frequency change with external voltage input. Upper frequency limited to maximum of selected range. Required external signal for full voltage control is 5 V with input impedance of 5 kΩ.

VCG Input Frequency

VCG Bandwidth: 100 kHz.
VCG Slew Rate: 2% of range per μs.

VCG Linearity

±0.2% for 10 Hz to 100 kHz.
±0.5% for 0.001 Hz to 1 MHz.

OPERATIONAL MODES

Continuous

Operating as a standard VCG frequency is determined by front panel control settings and VCG input signal.

Triggered

Only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector or push of manual trigger control. Trigger signal ≥1 V into 10 kΩ, dc coupled.

Gated

Same as triggered mode except that output oscillations continue for duration of gating signal.

Continuous Sweep

Main generator is swept by internal sweep generator so that frequency is swept from a low frequency established by front panel controls to a high frequency determined by SWEEP WIDTH control setting. Sweep width can be up to approximately 1000:1. Sweep rate determined by SWEEP TIME control is 10 μs to 100 s. GCV output appears at SWP/GCV connector.

Triggered Sweep

Same as continuous sweep mode except that output is swept only once for each pulse applied to TRIG IN connector. During time between sweeps, main generator oscillates at the start frequency.

Sweep and Hold

Gated sweep in which 50Ω output after sweep is the high frequency (set by SWEEP WIDTH control) for duration of gate signal at trigger input. When gate drops, output returns to frequency set by front panel frequency controls.

Tone Burst

Accomplished in gated mode by connecting ramp output of SWP/GCV output to trigger input. Tone burst rate, frequency, and duration can be independently controlled.

HORIZONTAL PRECISION

Frequency Readout Accuracy

0.01 Hz to 10 kHz ±(0.3% of range ±1 digit).
10 kHz to 10 MHz ±(0.2% of range ±1 digit).

Time Symmetry

±0.5% for 10 Hz to 100 kHz.
±1.0% for 0.01 Hz to 500 kHz.

VERTICAL PRECISION

Amplitude Readout Accuracy

1 Hz to 100 kHz ±(3% of full output ±1 digit).
100 kHz to 10 MHz ±(5% of full output ±1 digit.
Note: Display is 50Ω terminated voltage. For operation in 0.01 Hz or 0.1 Hz range, amplitude display is instantaneous voltage value in a tracking mode. Readout updated approximately 3 times per second.

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.2 dB to 1 MHz.
2.0 dB to 10 MHz.

Step Attenuator Accuracy

±0.25 dB/20 dB.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All waveforms (except pulse) symmetrical about ground within ±1% of maximum p-p amplitude.

PURITY

Sine Wave Distortion

Less than:
0.5% (typically 0.25%) for 10 Hz to 100 kHz.
1.0% for 100 kHz to 1 MHz.
All harmonics at least 30 dB down for 1 MHz to 10 MHz.

Triangle Linearity

Greater than 99% for 0.0005 Hz to 100 kHz.

Square Wave Rise and Fall Time

Less than 30 ns (terminated into 50Ω load).

Total Aberrations

Less than 5%.

ENVIRONMENTAL

All specifications listed, except stability, are for 25°C ±5°C. For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

14½ in./36.8 cm wide, 5¼ in./13.3 cm high; 14¼ in./36.2 cm deep.

Weight

12 lb/5.45 kg net, 16 lb/7.26 kg shipping.

Power

90 V to 110 V, 105 V to 125 V, 180 V to 220 V or 210 V to 250 V; 50 Hz to 400 Hz.
Less than 50 watts.

Note: Specifications apply from 10% to 100% of a selected frequency range. Prices and specifications subject to change.

ORDER INFORMATION

Model 147 — $1295 (FOB San Diego)

SERIES 150 PROGRAMMABLE FUNCTION GENERATORS

The 150 Series offers the most complete line of programmable signal sources available. The product line begins with the Models 150 and 155. The 155 features front panel control as well as remote; the Model 150 has remote control only. These two units provide sine, triangle, and square wave output up to 1 MHz in frequency.

Our newest instruments are the Models 158 and 159. These "breakthrough" instruments greatly extend the utility of programmables. The 159 gives local and remote control, while the 158 is remote only. The 159 features keyboard data entry with digital display. Both feature sine, triangle, square, and ramp waveforms, simple ASCII programming, programmable dc offset, triggered and gated operation, and a 3 MHz top frequency.

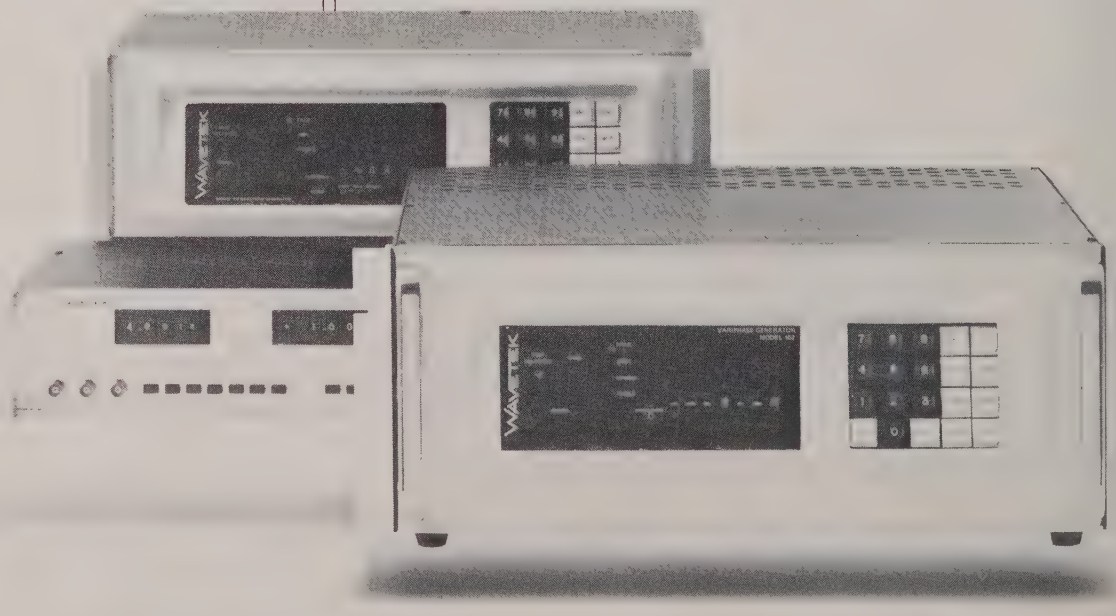
Where increased versatility is needed, the Model 154 offers 10 MHz top frequency, amplitude and frequency modulation, programmable dc offset as well as dc volts and triggered and gated operation.

If the requirement is for greater precision, the Model 157 Waveform Synthesizer is the solution. Covering frequencies from 100 μHz to 1 MHz with accuracies of 0.01%, the 157 meets the critical demands of most automatic test systems. Other features include frequency lock to an external source, precision amplitude attenuation, and triggered and gated operation.

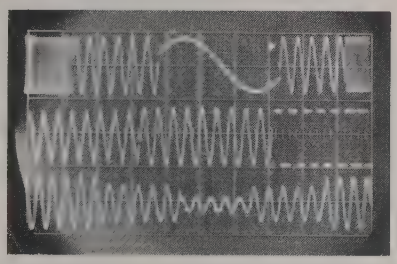
The newest addition to the line is the Model 152 Variphase Generator. Each Model 152 can output 1 to 4 channels of waveforms and can control the phase between all four from 0° to 360°. Other features include 0.1° phase control, 0.05% harmonic distortion for the sine wave, external phase lock, sine/cosine output, sine, triangle, and square wave output, and a top frequency of 100 kHz. The Model 152 also features keyboard data entry with digital display and remote control.

SELECTION GUIDE

Features	Model 150	152	154	155	157	158	159
Basic Waveforms: ∿, ⊓, ◺	X	X	X	X	X	X	X
Ramp ◿, ◹	—	X	—	—	—	X	X
Waveform Inverting ∩, ⊓, ∨	—	X	—	—	—	X	X
DC Voltage Output	—	X	X	—	—	X	X
VCG for Frequency Modulation	X	—	X	X	X	X	X
Upper Frequency (MHz)	1	0.2	10	1	1	3	3
Lower Frequency (mHz)	10	10[3]	1	10	0.1	100	100
VCA for Amplitude Modulation	—	—	X	—	—	—	—
Amplitude Control	X	X	X	X	X	X	X
Dynamic Amplitude Range (into 50Ω):							
Upper (V p-p)	10	20	10	10	10	10	10
Lower (mV p-p)	10	1	1	1	1	20	20
Programmable DC Offset	—	X	X	—	—	X	X
Triggering and Gating	X	—	X	X	X	X	X
Accepts External Sync	—	X	—	—	X	—	—
Multiple Outputs	X	X	—	X	—	—	—
Continuous Variable Phase	—	X	—	—	—	—	—
Programming:							
BCD	X	—	X	X	X	Option	
7-Bit Parallel	—	X	—	—	—	X	X
Local Control	—	X	X	X	X	—	X
Digits of Resolution:							
Frequency	3	3	3	3	5	3	3
Amplitude	3	3	3	3	3	3	3
DC Offset	—	3	3	—	—	3	3
Phase	—	4	—	—	—	—	—



MODELS 150/155 PROGRAMMABLE VCG GENERATORS



The Models 150 and 155 Programmable Voltage Controlled Generators are precision sources of sine, square, and triangle waveforms that are designed for automatic system application. The Model 155 has local and remote digital control (Model 150 remote only) of frequency, function, and amplitude. In the Model 155, local control is with front panel switches. Additionally, both generators may be controlled by analog voltage in the following manner: the frequency may be programmed or modulated by an ac or dc signal. Generator output may be initiated by means of a trigger which will generate one complete cycle, and/or a gate input which will provide a signal burst of an integral number of cycles for the duration of the applied gate. The frequency range consists of eight decade ranges with three decimal digits of resolution covering the dynamic range of 0.01 Hz to 1 MHz. The signal amplitude consists of three decade ranges with three decimal digits of resolution covering the dynamic range of 0.01 volt to 10 volts peak-to-peak. Output range scaling is accomplished using an attenuator with 50 ohm output impedance on all ranges. All specifications require that the output be terminated by a 50 ohm load. The functions and modes are selected by a multiple deck switch. All these controls may be activated remotely by contact closures through a 50 pin connector on the rear panel of both models. The three digit control of frequency and amplitude is 8421 BCD coded with only 12 lines required for each. The ranges and functions are controlled by one line per function. Standard interface options are available so that any logic input may be converted in the instrument to provide proper information control. These programmable VCGs may be driven by computers, punched cards, or tape and servo switch devices. They are useful in automatic test systems, automatic control tools, production test stands, and as precision laboratory test generators.

They are useful in automatic test systems, automatic control tools, production test stands, and as precision laboratory test generators.

VERSATILITY

Waveforms

Sine ∿, square ⊓, and triangle △.

Dynamic Frequency Range

0.01 Hz to 1 MHz in 8 ranges.

Outputs

1. ∿, ⊓, △ selectable and digitally variable from 0.01 V to 10 V p-p into a 50Ω load in 3 ranges with 3 digit resolution.
2. ∿ 1 V p-p into 50Ω load.
3. △ 1 V p-p into 50Ω load.
4. ⊓ 0.5 V p-p into 50Ω load.

VCG Analog Voltage Control

Over 20:1 frequency ratio with 0 to 5 V control signal. Analog frequency control and/or modulation. Input impedance of 10 kΩ.

VCG Bandwidth

100 kHz.

VCG Linearity

±0.2% to 100 kHz.

Operational Modes

Operates in continuous or triggered mode. In the triggered mode, a pulse generates at least 1 cycle and a gate signal produces a burst of cycles.

Trigger/Gate Signal

Input voltage: +5 V to +100 V. (−5 V to −100 V on request.) Input impedance: 10kΩ.

HORIZONTAL PRECISION

Frequency Accuracy

0.01 Hz to 0.1 Hz ±(2% of setting +1 digit).
0.1 Hz to 100 kHz ±(1% of setting +1 digit).
100 kHz to 1 MHz ±(5% of setting +1 digit).

VERTICAL PRECISION

Amplitude Accuracy

Output 1:
0.01 Hz to 100 kHz ±(1% of setting +1 digit).
100 kHz to 1 MHz ±(5% of setting +1 digit).
Outputs 2 thru 4:
±1% of stated output.

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.5 dB to 1 MHz.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to frequency, amplitude, and dc offset stability.

Amplitude Symmetry

All waveforms symmetrical about ground within ±1% of maximum p-p amplitude.

PURITY

Sine Wave Distortion

Less than:
1% for 0.01 Hz to 99.9 kHz.
3% for 100 kHz to 1 MHz.

Triangle Linearity

Greater than:
99% for 0.01 Hz to 99 kHz.
95% for 100 kHz to 1 MHz.

Square Wave Rise and Fall Time

Less than:
10 ns Output 4
150 ns Output 1

PROGRAMMING

Basic units programmable by remote contact closure. Frequency, function, and amplitude may all be programmed. Frequency and amplitude have 3 digit resolution programmed by 8421 BCD code. Range and function selection direct line contact. Model 150 has remote programming only. Model 155 has local and remote control. Local switches override remote programming.

INTERFACE OPTIONS

Standard (Contact Closure) 8421 Code

60 mA/line maximum.

Option 2 (Logic Level) 8421 Code

"1" = ±3.5 V to ±20 V, 15 mA/line maximum.
"0" = 0 V to ±0.5 V.

Option 3 (Logic Level) 8421 Code

"1" = 0 V to ±0.5 V.
"0" = ±3.5 V to ±10 V, 15 mA/line maximum.

Note: Consult factory for other options available.

ENVIRONMENTAL

Specifications apply for 25°C ±5°C. For operation from 0°C to 50°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

19 in./48.3 cm wide, 5¼ in./13.3 cm high, 16¼ in./41.3 cm deep.

Weight

10 lb/4.5 kg net, 15 lb/6.8 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 25 watts.

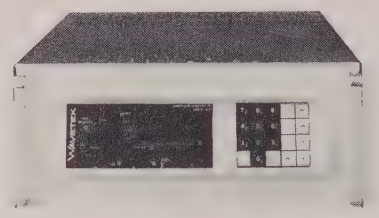
Note: Specifications apply from 10% to 100% of selected range. Prices and specifications subject to change.

ORDER INFORMATION

(FOB San Diego)

Model 150	**$1195**
Model 155	**$1395**
Option 2	**$ 600**
Option 3	**$ 600**

MODEL 152 VARIPHASE GENERATOR



The Model 152 Variphase Generator is a precision source of multiple waveforms with variable phase relationship for use in your systems requirements. The standard two channel system provides the capability to independently program amplitude, offset, and waveform for each channel. The phase relationship of the sine and square wave is referenced to the sync output and is variable with four digit resolution. The Model 152 Variphase Generator is easily programmed either by the front panel keyboard or by serial ASCII coded characters from a remote source.

The versatility of this unique instrument plus the low distortion sine wave output (less than 0.1% total harmonic distortion to 10 kHz) make it the ideal instrument for automatic test applications or laboratory requirements.

VERSATILITY

Waveforms

Sine ∿, cosine ∿, triangle ∿, square ⎍, variphase sine, variphase square, and dc selectable. All waveforms except triangle and variphase sine may be inverted by changing the polarity of the peak amplitude programming.

Frequency Range

1 Hz to 100 kHz in 5 ranges with 3 digit resolution.

10^0	1 Hz to 9.99 Hz
10^1	10 Hz to 99.9 Hz
10^2	100 Hz to 999 Hz
10^3	1 kHz to 9.99 kHz
10^4	10 kHz to 99.9 kHz

Main Output

DC voltage, ±10 mV dc to ±9.99 V dc at 100 mA maximum. Output impedance less than 1Ω. Sine, triangle, square, variphase sine and variphase square, 10 mV peak to 9.99 V peak at 100 mA peak maximum output current in 3 ranges (10^0, 10^{-1}, 10^{-2}). The output impedance is less than 1Ω and may be loaded by less than 1000 pF distributed capacitance in the form of connecting cables.

DC Offset

All waveforms may be offset 9.99 V above or below ground level with 3 digit resolution and selectable polarity. Signal level plus offset voltage must not exceed ±9.99 V peak.

Sync Output

A TTL compatible 0.4 V to 2.5 V square wave output, which provides 16 mA sinking current to sync up to 10 TTL loads. The positive rising edge of the square wave is in phase with zero degree phase of the sine wave.

Sync Input

Generator may be synchronized to an external, time symmetrical signal of at least 1 V peak and within 1% of the programmed frequency. Both sine and square waveforms may be phase-shifted with respect to the external sync signal. The accuracy of the phase-shifted waveform is defined with respect to the reference channel output, and is not referenced to the sync input.

ACCURACY

Horizontal Precision (Frequency Accuracy)

1 Hz to 10 kHz ±(1% of program +0.1% of range).

10 kHz to 100 kHz ±(2% of program +0.1% of range).

Vertical Precision (Amplitude Accuracy)

Square and Variphase Square Waveforms:

1 Hz to 10 kHz ±(1% of program +0.1% of range).

10 kHz to 100 kHz ±(3% of program +0.1% of range).

Sine, Cosine and Variphase Waveforms:

1 Hz to 10 kHz ±(3% of program +0.1% of range).

10 kHz to 100 kHz ±(5% of program +0.1% of range).

Triangle Waveform:

1 Hz to 10 kHz ±(2% of program +0.1% of range).

Sine Wave Frequency Response

Amplitude change with frequency less than:

0.3 dB to 10 kHz.

0.5 dB to 100 kHz.

Phase Angle

Variphase Sine:

±0.3° to 1 kHz.

±1° to 10 kHz.

±4° to 100 kHz.

Variphase Square:

±0.5° to 1 kHz.

±1.5° to 10 kHz.

±5° to 100 kHz.

Stability

Short term: ±0.05% for 10 minutes.

Long term: ±0.25% for 24 hours.

PURITY

Sine Wave Distortion

Sine and Cosine Waveforms (all harmonics):

60 dB down to 10 kHz (less than 0.1% total harmonic distortion).

43 dB down to 100 kHz (less than 0.7% total harmonic distortion).

Variphase Sine Waveform (all harmonics):

60 dB down to 1 kHz (less than 0.1% total harmonic distortion).

52 dB down to 10 kHz (less than 0.25% total harmonic distortion).

42 dB down to 100 kHz (less than 0.8% total harmonic distortion).

Triangle Linearity
Greater than 99% to 10 kHz.

Square Wave Rise and Fall Time
Less than 3 μs for 20 V p-p (6.5 V/μs).

Total Aberrations
Less than 5% of program value ±10 mV.

ENVIRONMENTAL

Specifications apply for 25°C ±5°C. For operation from 0°C to +55°C, derate all specifications by a factor of 2. Unit may be stored from −40°C to +75°C without damage.

MECHANICAL

May be used on the bench or in a 19 inch rack. Rack adapter hardware and program mating connectors included.

Dimensions
17¼ in./43.8 cm wide, 7 in./17.8 cm high, 23½ in./59.7 cm deep.

Weight
43 lb/19.5 kg net, 52 lb/23.6 kg shipping.

Power
90 V to 110 V, 105 V to 125 V, 180 V to 220 V, or 210 V to 250 V; 50 Hz to 400 Hz. Less than 150 watts.

Note: Specifications apply for control settings from 1.00 to 9.99. Prices and specifications are subject to change.

PROGRAMMING DESCRIPTION

The Model 152 is programmed by a serial stream of ASCII coded characters. Instructions are in a 7 bit parallel ASCII code. The input format is designed to accept scientific notation. A character is presented to the interface with a clock pulse. Each 152 in the system has an address. Once addressed, it will accept the data on the bus. This type of addressing feature allows up to 9 units to be controlled from one I/O slot. The Model 152 with its front panel push button control may be used to manually enter data into any other Model 152 or Wavetek Model 158 or 159 Waveform Generator in the system.

Optional interfaces are available for HP 2100, PDP 11, TTY, RS 232, and BCD parallel.

LOGIC LEVEL REQUIREMENTS

State	Requirements
Low (Logic "1")	0 V to 0.4 V sinking 25 mA maximum
High (Logic "0")	2.4 V or open

Notes:
1. *Open input is 3.0 V.*
2. *Input is terminated by 220Ω to +5 V and 330Ω to ground.*
3. *Recommended driver: SN 7438.*

PROGRAMMING TRANSITION TIME

Unit accepts bytes at a 1 MHz rate. The output will become stable within 100 μs unless the range digit is changed; then output will be stable within 1 ms.

ISOLATION

Signal ground and program ground are common in the standard 152. Optical isolation is available. Order Option 152-001.

PROGRAMMING SEQUENCE

1. Unit; GX
2. Channel; BX
3. Freq; FXXX
4. Freq Exp; FESpX
5. Ampl; ASpXXX
6. Ampl Exp; AEX
7. Offset; DSpXXX
8. Function; CX
9. Phase; HXXXX
10. Exec; I

Note: 1. Steps 2, 3, and 4 must be preceded by Step 1.
2. Steps 5, 6, 7, and 8 must be preceded by the selection of a channel.

INPUT CONTROL LINES AND CONNECTOR LAYOUT

Mating Connector: Molex 03-09-2151 with 02-09-2118 pins. 1 mating connector furnished

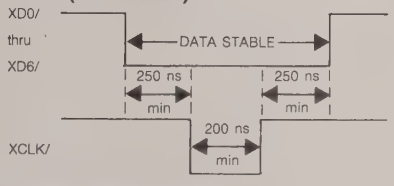
Pin No.	Designation	
13	XD0/	Least significant bit
11	XD1/	Input data lines
8	XD2/	
10	XD3/	
9	XD4/	
12	XD5/	
14	XD6/	Most significant bit
15	XCLK/ Clock control	
4	+5 V dc, 200 mA max source	
7	Common	
3	Keyboard lockout/	

KEYBOARD TO ASCII CONVERSION TABLE

Keyboard	ASCII	Keyboard	ASCII
AMPL	A	MULT	(Space) or E
UNIT	G	ANGL	H
OFST	D	EXEC	I
CHNL	B	0 thru 9	0 thru 9
FUNC	C	—	−(Minus)
FREQ	F		

TIMING

Direct (No Isolation)



ORDER INFORMATION

(FOB San Diego)

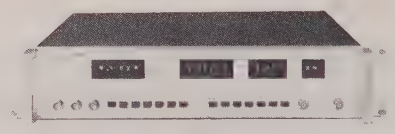
Model 152 Programmable Only **$4995**
Model 152 With Keyboard **$5490**

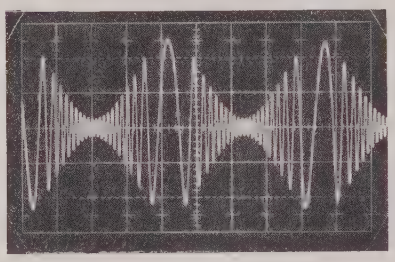
Options

152-001 Additional Output Channel **$995**

Note: Interface options for most computers and additional channels are available on special request. Contact your Wavetek representative for further information.

MODEL 154 PROGRAMMABLE FUNCTION GENERATOR





The Model 154 Programmable Voltage Controlled Generator is a precision source of sine, square, and triangle waveforms and dc voltage output. The Model 154 has local and remote digital control of frequency, function, offset, and amplitude. Additionally, the frequency, dc level, and/or the amplitude of the generator may be programmed or modulated by an external ac or dc signal. Generator output may be initiated by means of a trigger which will generate one complete cycle, and/or a gate input which will provide a signal burst of an integral number of cycles for the duration of the applied gate.

In the Model 154, programming is accomplished using front panel switches or remote DTL/TTL input. The frequency range consists of 10 decade ranges with 3 decimal digits of resolution covering the dynamic range of 0.001 Hz to 10 MHz. The signal amplitude consists of 3 decade ranges with 3 decimal digits of resolution covering the dynamic range of 0.001 volt to 10 volts peak-to-peak. Output range scaling is accomplished using an attenuator with 50Ω output impedance on all ranges. The dc voltage output is from a source impedance of less than 1 ohm. Polarity is selectable and the voltage may be programmed from 0.1 V to 10 V with three digit resolution.

The system interface has been designed to insure rapid systems integration with minimum problems. All programming is compatible with DTL/TTL logic level inputs. Signal and program common are isolated to eliminate system ground loops. Front panel controls may be set to override remote control allowing special formatting, easy checkout, and maintenance.

The combination of extremely broad signal range, frequency accuracy, and programmability make this instrument ideally suited for the demanding requirements of automatic system testing. It may be programmed by computers, paper tape, magnetic tape, IBM cards, servo switches, or remote control stations.

Applications include:

Precision ac or dc signal source for automatic systems testing.

Precise source of discrete frequency changes for audiometric research.

Muscle and tissue stimulus for biomedical research.

Low frequency triangle waveform for metal testing to determine elongation and modulus of elasticity of samples.

Precision source for the determination of soil compressibility in geophysical studies.

Programmable digital-to-analog converter.

VERSATILITY

Waveforms

Sine ∿, square ⊓, triangle △, and dc voltage, with auxiliary pulse output.

Dynamic Frequency Range

0.001 Hz to 10 MHz in 10 decade ranges.

Main Output

Sine, square, and triangle selectable from 0.001 V to 10 V p-p into 50Ω load. Output impedance 50Ω. DC voltage of ±0.1 V to 10 V at 100 mA maximum. Output impedance less than 1Ω.

Auxiliary Output

50% duty cycle pulse at the generator frequency. Fixed amplitude with peak output of 0 to +6 V into open circuit (0 to 3 V into 50Ω).

DC Offset

±5 V offset controlled from front panel or by remote programming with 3 digit resolution and selectable polarity. Signal sensitivity is 2 V offset per volt input. Input impedance is 3.3 kΩ. Signal level plus offset voltage not to exceed peak output of ±7.5 V into 50Ω load.

DC Offset Linearity

1% of full scale.

Analog Modulation Control

Frequency, amplitude, and dc offset level of the generator can be independently controlled by an external voltage. The control can be dc programming or wide band ac modulation.

Operational Modes

Continuous, triggered, or gated mode selectable. The generator may be triggered to produce single cycles by push button or external trigger command. Any discrete number of cycles will be produced by applying a gate signal for the desired burst width when in the gated mode. Minimum voltage required for trigger is +3 V (50 V can be applied without damage).

ANALOG CONTROL CHARACTERISTICS

VCG Control Range

Up to 1000:1 frequency change with external voltage input of 5 V with input impedance of 3.3 kΩ. Upper frequency limited to maximum of selected range.

VCG Input Frequency

VCG Bandwidth: 100 kHz.
VCG Slew Rate: 2% of range per μs.

VCG Linearity

±0.2% for 1.0 Hz to 100 kHz.
±0.5% for 0.001 Hz to 1 MHz.

VCA — Voltage Control of Amplitude

Full amplitude control with external input of ±5 V. Amplitude can be controlled from maximum through null to range maximum at inverted phase. VCA input impedance of 3.3 kΩ.

VCA Response

Bandwidth: 100 kHz.
Slew Rate: 2% of range per μs.

VCA Linearity

1% of full scale.

HORIZONTAL PRECISION

Frequency Accuracy

0.001 Hz to 100 kHz ±(1% of setting +1 digit).
100 kHz to 1 MHz ±(1% of full scale).
1 MHz to 10 MHz ±(2% of full scale).

Time Symmetry

±1% for 0.01 Hz to 500 kHz.

VERTICAL PRECISION

Amplitude Accuracy

Accuracy stated is for X 1 amplitude range. For X 0.1, X 0.01 and X 0.001, add 1% per step.

∿ and ⊓ Waveforms:
0.001 Hz to 100 kHz ±(1% of setting +1 digit).
100 kHz to 1 MHz ±(2% of setting +1 digit).
1 MHz to 10 MHz ±(5% of setting +1 digit).

∿ Waveform:
0.001 Hz to 10 kHz ±(1% of setting +1 digit).

DC Voltage

±(1% of setting +1% of full scale).

DC Offset

±(1% of setting +1% of range).

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to frequency, amplitude, and dc offset stability.

Amplitude Symmetry

All waveforms to 500 kHz symmetrical about ground within ±1% of maximum p-p amplitude.

PURITY

Sine Wave Distortion

Less than:
0.5% for 10 Hz to 100 kHz.
1.0% for 0.001 Hz to 1 MHz.
All harmonics at least −28 dB for 1 MHz to 10 MHz.

Triangle Linearity

Greater than:
99% for 0.01 Hz to 100 kHz.

Square Wave Rise and Fall Time

Less than:
Auxiliary Output 5 ns
Main OUtput 35 ns

Total Aberrations

Less than 5% +10 mV.

DC Voltage

Ripple and noise less than 10 mV rms with generator idle.

ENVIRONMENTAL

Specifications apply for 25°C ±5°C. For operation from 0°C to 50°C, derate all specifications by a factor of 2. Unit may be stored from −50°C to +85°C without damage.

MECHANICAL

Dimensions

19 in./48.3 cm wide (rack mount panel), 3½ in./8.9 cm high, 16½ in./41.9 cm deep.

Weight

15 lb/6.8 kg net, 24 lb/10.9 kg shipping.

Power

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 45 watts.

Note: Specifications apply for control settings from 1.00 to 9.99. On 1 MHz range, only X 1 and X 0.1 amplitude settings apply. Prices and specifications are subject to change.

PROGRAMMING

Description

All functions may be remotely controlled by BCD logic level programming. Front panel switches can be used to select local (front panel) or remote control. When all controls are in the remote position, a logic voltage output is enabled for computer verification as well as illumination of a front panel light for visual verification. Signal ground and program ground are isolated.

Standard Control Logic

Logic 1 = +2.4 V to +10 V (typical program connector input current is 1.5 mA per line).
Logic 0 = −1 V to +1 V (typical program connector open circuit voltage is 0.7 V).

Note: For optional logic, consult Wavetek.

Program Transition Time

Frequency, amplitude, and dc offset settings respond in less than 100 μs. Frequency range, function, offset polarity, and attenuator respond in less than 1 ms.

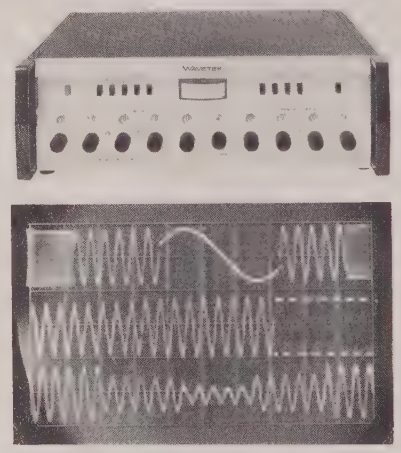
Program Requirements

Frequency	3 digits	12 lines
Frequency range	10 ranges	4 lines
Amplitude	3 digits	12 lines
Amplitude range	4 ranges	2 lines
DC level	3 digits	12 lines
DC polarity	0, +, or −	2 lines
Function	∿ ⊓ ∿, or DC	2 lines
Mode	Cont, trig, or gate	2 lines
Output	Front or rear panel	1 line
Return		2 lines
All remote	Output for verification	1 line

ORDER INFORMATION

Model 154 — $1995 (FOB San Diego)

MODEL 157 PROGRAMMABLE WAVEFORM SYNTHESIZER



The Model 157 Programmable Waveform Synthesizer is a precision source of sine, square, and triangle waveforms generated over a frequency range of 100 μHz to 1 MHz. This unique multifunction generator features:

- 0.01% frequency accuracy.
- 100 μHz (2.77 hr/cycle) to 1 MHz (1 μs) frequency range.
- Sine, square, and triangle waveforms.
- 1000:1 VCG.
- Triggered/gated operation.
- Selectable amplitude to 10 volts peak-to-peak.
- All parameters programmable.

The frequency, function, and amplitude of the generator can be controlled locally with front panel switching or remotely by BCD/binary programming. Frequency accuracy is 0.01 percent of programmed frequency with five digit resolution on each of ten ranges. The output voltage level can be programmed from 1 millivolt to 10 volts, peak-to-peak, in four ranges with 0.1 percent accuracy and three digit resolution.

The frequency of the Model 157 can be modulated about an accurately set center frequency by application of an ac voltage input. With a sawtooth input, the frequency can be swept over a 1000:1 ratio.

A trigger capability is included to allow a single cycle of any waveform, or a burst of cycles, when gated from an external source. In addition, a frequency search control is provided on the front panel that provides continuous sweep over the selected range with one turn of the control.

The combination of extremely broad signal range, frequency accuracy, and programmability make this instrument ideally suited for the demanding requirements of automatic system testing. It may be programmed by computers, paper tape, magnetic tape, IBM cards, servo switches, or remote control stations.

VERSATILITY

Waveforms

Sine ∿, square ⊓, and triangle △.

Dynamic Frequency Range

100 μHz (2.77 hr) to 1 MHz (1 μs) in 10 ranges.

Outputs

Sine, square, and triangle selectable and digitally variable from 0.001 V to 10 V p-p into a 50Ω load in 4 ranges with 3 digit resolution (0.002 V to 20 V p-p open circuit).

VCG — VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Over 1000:1 frequency ratio with 5 V input signal. Input impedance is 10 kΩ.

VCG Input Frequency

VCG Bandwidth: 1 MHz.
VCG Slew Rate: 100% of range per μs.

VCG Linearity

±0.1% for 100 μHz to 10 kHz.
±1.0% for 10 kHz to 100 kHz.
±3.0% for 100 kHz to 1 MHz.

OPERATIONAL MODES

Manual Cal

Generator is manually calibrated using the control loop but automatically returned to open loop condition to be swept or triggered.

Auto Cal

Generator has an automatic control loop to maintain the output frequency for high accuracy and stability.

Triggered

Generator may be triggered to produce single cycles on command or gated to produce any discrete number of cycles by applying a + gate signal to trigger input for length of the desired burst. Required gate voltage of +5 V to +50 V with input impedance of 10 KΩ.

Search

Generator frequency control within selected range is transferred from the digital controls to a single turn analog control for convenient manual sweeping of entire range.

Sync In

Within upper 4 ranges, instrument may be frequency synchronized to an external signal of approximately 1 V p-p within 1% of the free-running frequency. Induced sine distortion will be less than 1%.

Sync Out

Fixed amplitude square wave is brought out at 1 kΩ impedance for synchronizing scopes or other equipment.

HORIZONTAL PRECISION

Frequency Accuracy

Auto Cal Mode:
±(0.01% of setting +1 digit).
Manual Cal Mode:
±0.02% of setting.

Control Loop Settling Time
3 s max (1 ms for small-step changes).

VERTICAL PRECISION

Amplitude Accuracy
Peak-to-peak voltage range (up to 10 kHz):
1 mV to 100 mV ±(1% + 0.1 mV).
0.1 V to 1 V ±(1% + 1 mV).
1 V to 10 V ±(0.1% + 5 mV).

Sine Wave Frequency Response
Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.5 dB to 1 MHz.

Stability
Open Loop: ±0.05% for 8 hours.
Closed Loop: ±0.005% for 24 hours.
Percentages apply to frequency and amplitude.

Amplitude Symmetry
All waveforms symmetrical about ground within ±1% of maximum p-p amplitude. Trigger start-stop point will be 0 V ±0.5% of output amplitude program.

PURITY

Sine Wave Distortion
Less than:
0.5% for 100 μHz to 10 kHz.
1.0% for 10 kHz to 100 kHz.
3.0% for 100 kHz to 1 MHz.

Triangle Linearity
Greater than:
99% for 1 Hz to 100 kHz.
95% for 100 kHz to 1 MHz.

Square Wave Rise and Fall Time
Less than 100 ns.

ISOLATION
Output signal can be raised above ground to 250 V. Caution must be taken as all exposed BNC connectors are at raised potential.

REMOTE CONTROL

Configuration A (Standard)
True or Logic "1" = 0 V ±1 V.
Note: 0 V sinks approx 1.5 mA.
False or Logic "0" = +2 V to +10 V.
Note: Open circuit voltage approx. +2 V.

Configuration D
True or Logic "1" = +2 V to +10 V.
Note: +2 V sinks approx 1.5 mA.
False or Logic "0" = 0 V to +1 V.
Note: Open circuit voltage approx −0.7 V.

Program Transition Time
1 ms.

ENVIRONMENTAL
Specifications apply for 25°C ±5°C. For operation from 0°C to 50°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions
17 in./43.2 cm wide, 5¼ in./13.3 cm high, 14¼ in./36.2 cm deep.

Weight
22 lb/9.99 kg net, 27 lb/12.3 kg shipping.

Power
105 V to 125 V or 210 V to 250 V; 50 Hz to 400 Hz. Less than 50 watts.

Note: Specifications apply from 10% to 100% of range. Prices and specifications subject to change.

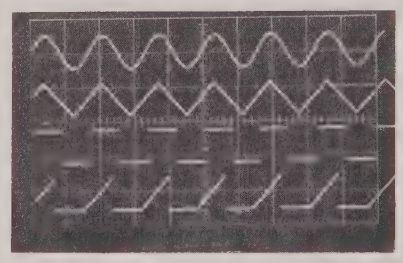
INTERFACE DATA

A	1	1st Decade Frequency (0-10)
B	2	
C	4	
D	8	
E	1*	
F	1	2nd Decade Frequency (0-9)
H	2	
J	4	
K	8	
L	1	3rd Decade Frequency (0-9)
M	2	
N	4	
P	8	
R	1	4th Decade Frequency (0-9)
S	2	
T	4	
U	8	
V	1	5th Decade Frequency (0-9)
W	2	
X	4	
Y	8	
Z	1	Frequency Ranges (See Note 1)
a	2	
b	4	
c	8	
d		−LOOP CONTROL
e		−TRIGGER CONTROL
f	1	1st Decade Amplitude (0-10)
h	2	
j	4	
k	8	
m	1*	
n	1	2nd Decade Amplitude (0-9)
p	2	
r	4	
s	8	
t	1	3rd Decade Amplitude (0-9)
u	2	
v	4	
w	8	
x	1	Amplitude Ranges (See Note 2)
y	2	
z	∿	Function
AA	⊓	
BB	∿	
CC		
DD		
EE		
FF		
HH		−PROGRAM COMMON

To program "10" in the most significant decade on frequency and amplitude, the code is 8, 1, and 1*.

ORDER INFORMATION
Model 157 — $2995 (FOB San Diego)

MODELS 158/159 WAVEFORM GENERATORS



- FULLY PROGRAMMABLE USING SIMPLE ASCII CODE
- KEYBOARD ENTRY FOR EASY LOCAL CONTROL
- DIGITAL DISPLAY OF FREQUENCY, AMPLITUDE, AND DC OFFSET
- SINE, TRIANGLE, SQUARE, AND RAMP WAVEFORMS
- FULL 3 MHz OUTPUT
- PROGRAMMABLE DC OFFSET AND VOLTAGE
- TRIGGERED AND GATED OPERATION

The Wavetek Model 159 Waveform Generator brings state-of-the-art keyboard design to the function generator. Now, with the touch of a finger, frequency, amplitude, waveform, mode, dc offset, etc. may be selected. The result of each operation is clearly shown on a digital LED display. There is not a single switch or dial to flip or turn. The greatest advantage of keyboard entry is that the Model 159 becomes fully programmable using the ASCII code and, as a result, may be used either on the bench or in a fully automatic test system.

Functionally, the Model 159 produces sine, triangle, square, and ramp waveforms. With a simple "−" (minus) command, the phase of the output waveform is changed 180 degrees. Triggered and gated modes are included for system synchronizing or for single and multiple cycle output (tone burst). The Model 159 provides three digit resolution of amplitude (20 mV to 10 V p-p into 50Ω), frequency (1 Hz to 3 MHz), and dc offset (0 to ±5 V into 50Ω). All of these functions may be remotely or locally programmed.

When the Model 159 is used in an automatic test system, the controller may lock out the keyboard so that the unit is under total computer control. To eliminate unwanted output transients during the program transition, the output may be disabled until the program is loaded, and then the output enabled. The digital display may be used to verify the data sent from the central processing unit and the most recent data may be recalled to the display.

A Model 158 is available for applications requiring remote programming only, since it has no keyboard or display. The unique programming concept for Models 158 and 159 requires only one keyboard no matter how many generators are used in a system. Furthermore, since the keyboard generates a standard ASCII code, any instrument in the system using this code may be programmed from one keyboard.

Programming is accomplished with only seven lines using the ASCII code. Several optional interfaces can be provided.

The combination of packaging, circuit design, and interface configuration makes the Models 158 and 159 attractive, extremely reliable, and easy to use waveform generators ideally suited for the demanding requirements both in the lab or in an automatic test system.

VERSATILITY

Waveforms

Sine ∿, triangle △, square ⊓, ramp ◿ (50% duty cycle), and auxiliary TTL sync pulse. All selectable waveforms may be inverted.

Frequency Range

Sine, triangle, and square from 1 Hz to 3 MHz in 7 ranges with 3 digit resolution.

10^0	1 Hz to 10 Hz
10^1	10 Hz to 100 Hz
10^2	100 Hz to 1 kHz
10^3	1 kHz to 10 kHz
10^4	10 kHz to 100 kHz
10^5	100 kHz to 1 MHz
10^6	1 MHz to 3 MHz

Ramp from 1 Hz to 1 MHz in 6 ranges ($10^0 \rightarrow 10^5$).

Main Output

Three digits of amplitude from 20 mV to 10 V p-p into 50Ω (20 V p-p into an open circuit) in 3 ranges (10^0, 10^{-1}, 10^{-2}).

DC Offset

Three digits of dc offset to ±5 V into 50Ω. DC offset plus waveform peak value may not exceed 10 V peak into open circuit or 5 V peak into 50Ω.

Sync Output

A TTL compatible 0 to 2.5 V square wave output, which provides 50 mA sinking current to sync up to 30 TTL loads.

Data Entry

Front panel keyboard/display and remote programming (Model 159).

Remote programming only (Model 158).

OPERATIONAL MODES

Continuous, triggered, and gated operation provided. In triggered mode, one cycle of selected signal output for each input trigger signal. In gated mode, signal output at selected frequency for duration of the input gate plus completion of the last cycle. 159 has front panel manual trigger.

Trigger/Gate Signal

Minimum:	+2 V.
Maximum:	50 V.
Input Impedance:	1 kΩ.

Note: Not sensitive to rise or fall times.

ANALOG MODULATION CONTROL

Frequency may be externally controlled by analog voltage (VCG) providing dc programming for FSK or wide band ac modulation. Input impedance is 5 kΩ.

VCG Control Signal

Approx 2.5 V: 1000:1 frequency change.
Approx 7.5 V: 300% overrange in first 5 ranges.

VCG Small Signal Bandwidth

100 kHz.

VCG Slew Rate

4% of range per μs.

ACCURACY

Horizontal Precision (Frequency Accuracy)

10 Hz to 100 kHz ±1% of program value ±1 digit.
100 kHz to 1 MHz ±2% of program value ±1 digit.
1 MHz to 3 MHz ±4% of program value ±1 digit.

Vertical Precision (Amplitude Accuracy)

Sine and Square Waveforms:
10 Hz to 100 kHz ±2% of program value ±1 digit.
100 kHz to 1 MHz ±5% of program value ±1 digit.
Triangle and Ramp Waveforms:
10 Hz to 10 kHz ±2% of program value ±1 digit.

DC Offset

±2% of program value.

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 100 kHz.
0.5 dB to 1 MHz.
1.0 dB to 3 MHz.

Stability

Short term:	±0.05% for 10 minutes.
Long term:	±0.25% for 24 hours.

PURITY

Sine Wave Distortion

Total harmonic distortion less than:
0.5% to 30 kHz.
1.0% to 300 kHz.
All harmonics:
34 dB down to 1 MHz.
30 dB down to 3 MHz.

Triangle Linearity

Greater than 99% to 100 kHz.

Square Wave Rise and Fall Time

Less than 50 ns.

Total Aberrations

Less than 5% of program value ±10 mV.

PROGRAMMING

The Models 158 and 159 are programmed by a serial stream of ASCII coded characters. Instructions are in a 7 bit parallel ASCII code. The input format is designed to accept scientific notation. A character is presented to the interface with a clock pulse. Each 158 or 159 in the system has an address. Once addressed, it will accept the data on the bus. This type of addressing feature allows up to 9 units to be controlled from one I/O slot. The Model 159 with its front panel push button control may be used to manually enter data into any other 158, 159, or Wavetek Model 152 Variphase Generator in the system.

Optical interfaces are available for HP 2100, PDP 11, TTY, RS 232, and BCD parallel.

Logic Level Requirements

State	Requirements
Low (Logic "1")	0 V to 0.4 sinking 25 mA maximum
High (Logic "0")	2.4 V or open

Notes:

1. *Open input is 3.0 V.*
2. *Input is terminated by 220Ω to +5 V and 330Ω to ground.*
3. *Recommended driver:SN 7438.*

Transition Time

Unit accepts bytes at a 1 MHz rate. The output will become stable within 100 μs unless the range digit is changed; then output will be stable within 1 ms.

Isolation

Signal ground and program ground are common in the standard 158/159. Optical isolation is available. Order Option 159-001.

Input Control Lines and Connector Layout

Mating Connector: Molex 03-09-2151 with 02-09-2118 pins; 1 mating connector furnished

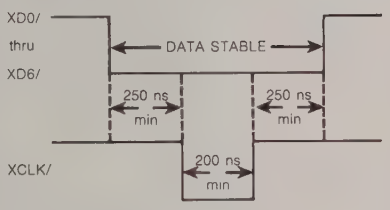
Pin No.	Designation	
13	XD0/	Least significant bit
11	XD1/	
8	XD2/	
10	XD3/	Input data lines
9	XD4/	
12	XD5/	
14	XD6/	Most significant bit
15	XCLK/	Clock control
4	+5 V dc, 200 mA max source	
7	Common	
3	Keyboard lockout/	

Keyboard To ASCII Conversion Table

Keyboard	ASCII	Keyboard	ASCII
AMPL	A	MULT	(Space) or E
UNIT	G	ON	H
OFST	D	OFF	I
MODE	B	0 thru 9	0 thru 9
FUNC	C	.	.
FREQ	F	—	— (Minus)

Timing

Direct (No Isolation)



ENVIRONMENTAL

Specifications apply for 25°C ±5°C. For operation from 0°C to +55°C, derate all specifications by a factor of 2. Unit may be stored from −40°C to +75°C without damage.

MECHANICAL

May be used on the bench or in a 19 in. rack. Rack adapter hardware and program mating connectors included.

Dimensions

17¼ in./43.8 cm wide, 5¼ in./13.3 cm high, 17 in./43.2 cm deep.

Weight

15 lb/6.8 kg net, 23 lb/10.4 kg shipping.

Power

90 V to 110 V, 105 V to 125 V, 180 V to 220 V, or 210 V to 250 V; 50 Hz to 400 Hz. Less than 45 watts.

Note: Specifications apply for control settings from 1.00 to 9.99. Prices and specifications are subject to change.

ACCESSORIES

Model 580 Manual Remote Programmer

The Model 580 allows remote manual programming. The separate console contains a keyboard and display and may be located up to 100 feet from the instrument it is programming. The Model 580's space-saving size makes it ideal for production testing.

Model 581 Interface Card for HP 2100 Computer

The Model 581 interface card will plug directly into the HP 2100 I/O slot and allow full digital control of the Wavetek Model 158 or 159.

Model 582 Interface Card for PDP11 Computer

The Model 582 interface card will plug directly into the PDP 11 I/O slot and allow full digital control of the Wavetek Model 158 or 159.

OPTIONS

Option 159-001 Isolated Digital Input

Provides complete isolation between program and signal common by optical isolators on each input line.

Option 159-002 TTY Remote Control Interface

Allows full remote control from a teletype or other two-wire ASCII coded controller. Only one interface is required per system. Up to nine units may be controlled from one teletype.

Option 159-003 RS 232 Remote Control Interface

Allows full remote control from a CRT terminal using RS 232 format. Only one interface required per system. Up to nine units may be controlled from one terminal.

Option 159-004 BCD Parallel Remote Control Interface

Allows digital control of all functions. Approximately 50 lines required. TTL compatible. Logic "1" state low.

ORDER INFORMATION

(FOB San Diego)

Model 158		**$1245**
Model 159		**$1495**
Options		
159-001	Isolated Digital Input	**$150**
159-002	TTY Remote Interface	**$150**
159-003	RS 232 Remote Interface	**$150**
159-004	BCD Parallel Remote Interface	**$400**
Accessories		
Model 580	Manual Remote Programmer	**$395**
Model 581	Interface Card for HP 2100 Computer	**$250**
Model 582	Interface Card for PDP 11 Computer	**$250**

MODELS 162/164 FUNCTION GENERATORS

The Wavetek Models 162 and 164 Function Generators offer an exciting new waveform versatility for function generators—plus a frequency range that spans twelve decades, from 30 μHz (9.2 hours per cycle) to 30 MHz.

Besides the sine, square, triangle, positive pulse, and negative pulse waveforms (all with controllable symmetry), Wavetek introduces the trapezoidal outputs: positive, negative, and balanced waveforms.

The trapezoidal waveforms enhance the utility of function generators in that their rise and fall times may be varied by means of independent slope, width, and symmetry controls. Different rise and fall times, both controllable, may be selected to suit your testing or triggering requirements. An adjustable dc output is provided for voltage reference.

The Model 162 employs a single generator, which can be triggered, gated, or swept by an external signal. The Model 164 uses this same generator as its main generator and, in addition, has a ramp/step generator. The latter is used to sweep, sweep burst, or step the frequency of the main generator. Frequency sweeping and stepping may be up or down. Steps may be automatically sequenced or triggered.

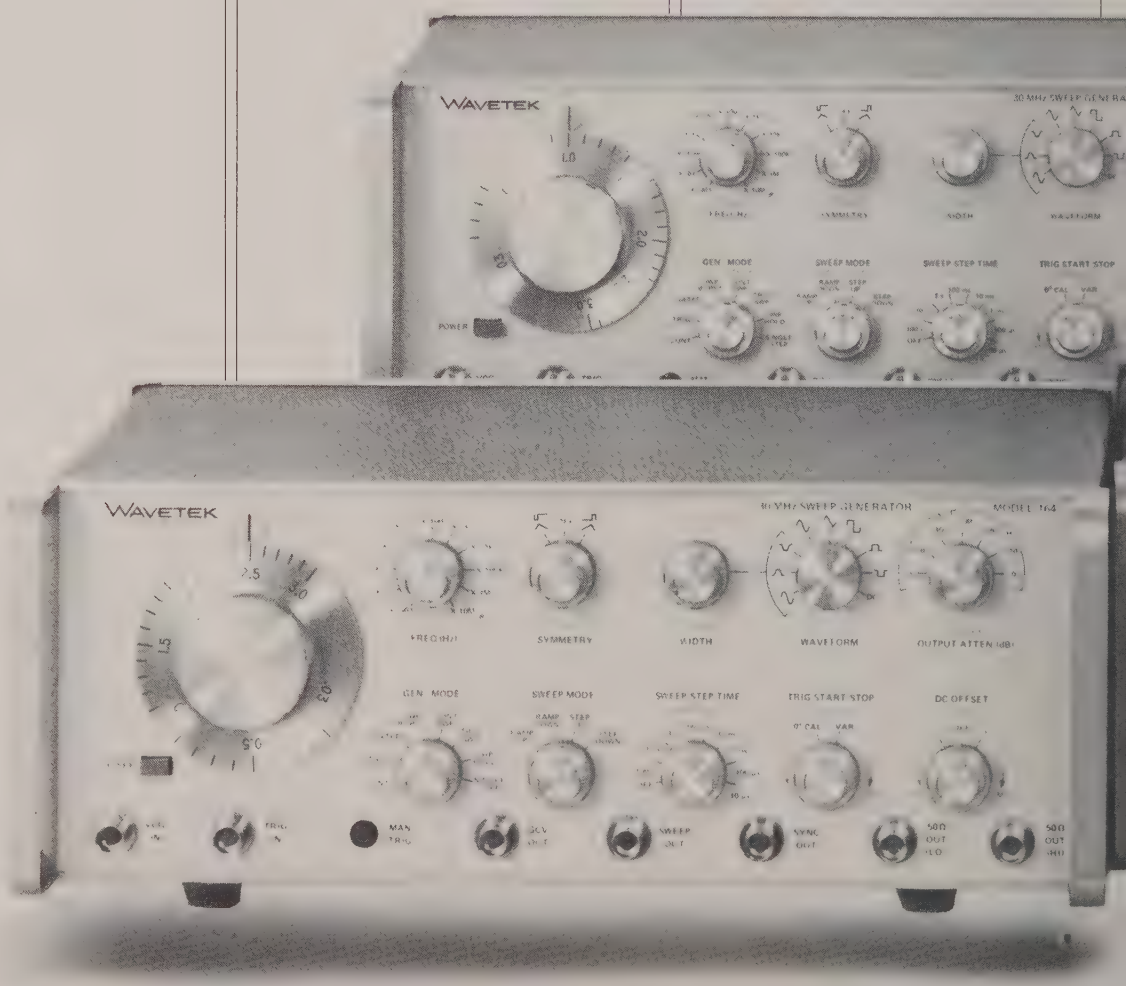
MODEL 162

- 30 MHz Top Frequency
- Variable Rise and Fall Times
- 9.2 Hours-per-Cycle Low Frequency
- Triggered and Gated Operation
- Variable Start/Stop Point
- Nine Selectable Outputs

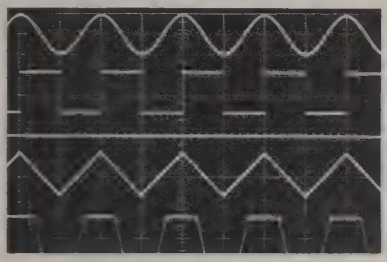
Broad frequency range, waveform diversity, and cost effective combination of performance and features make these two generators the ultimate in laboratory signal sources.

MODEL 164

- All of the Model 162 Features plus . . .
- Sweep Up or Sweep Down
- Step Frequency Up or Down in 10% Steps
- Automatic or Triggered Frequency Stepping
- Sweep Burst Mode
- Sweep Generator Output and Voltage Output Proportional to Frequency

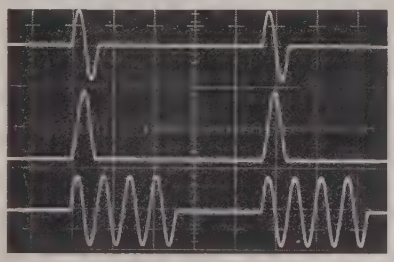


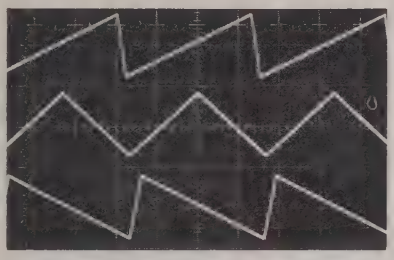
Eight Selectable Waveforms Plus DC Voltage Output for Maximum Waveform Versatility



Trapezoidal Waveforms with Control of Width, Symmetry, and Slope Give Pulses with Variable Rise and Fall

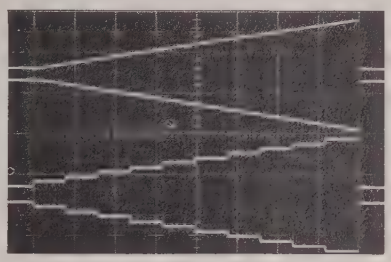
Triggered or Gated Operation with Variable Start/Stop Control Allows the Phase of Any Waveform to Be Continuously Varied from −90° to +90°

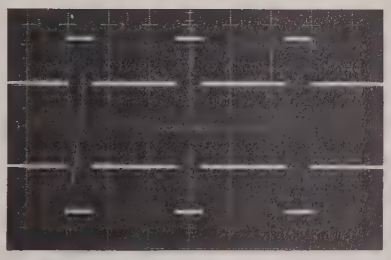




Variable Symmetry Control on All Waveforms to Create Ramp or Pulse Waveforms with Adjustable Duty Cycle

Ramp Up, Ramp Down, Step Up, or Step Down for the Ultimate in Sweep or Point-by-Point Frequency Testing





Positive, Negative, or Balanced Output with Variable Duty Cycle and Variable Offset Capability

MODEL 162 THIRTY MHz FUNCTION GENERATOR

VERSATILITY

Waveforms

Eight selectable waveforms, sine ∿, square ⊓, triangle △, positive pulse ⎍, negative pulse ⎏, trapezoid ⏢, positive trapezoid ⏢, and negative trapezoid ⏢, plus variable dc output. Symmetry of all outputs continuously adjustable from 1:19 to 19:1. Varying symmetry provides variable duty-cycle pulses, sawtooth or unsymmetrical trapezoidal waveforms. Separate sync output included.

Operating Frequency Range

0.00003 Hz to 30 MHz in 11 ranges:

X 0.001	0.00003 Hz to 0.003 Hz
X 0.01	0.0003 Hz to 0.03 Hz
X 0.1	0.003 Hz to 0.3 Hz
X 1	0.03 Hz to 3 Hz
X 10	0.3 Hz to 30 Hz
X 100	0.3 Hz to 300 Hz
X 1K	3 Hz to 3 kHz
X 10K	30 Hz to 30 kHz
X 100K	300 Hz to 300 kHz
X 1 MHz	3 kHz to 3 MHz
X 10 MHz	30 kHz to 30 MHz

Note: When SYMMETRY control is used, indicated frequency is divided by approximately 10.

Main Output

Maximum output of sine, triangle, square, and trapezoidal waveforms is 20 V p-p into open circuit and 10 V p-p into 50Ω load. Positive and negative trapezoids and pulses are 10 V peak into open circuit and 5 V peak into 50Ω. DC voltage is adjustable between ±10 volts, 50Ω source impedance. Output peak current is 130 mA minimum for all waveforms and dc. Precision output allows from 0 dB to −60 dB attenuation in 10 dB steps with a 20 dB vernier; maximum overall attenuation is −80 dB. High level 0 to −50 dB and low level −40 to −80 dB outputs give optimum performance.

Sync Output

Approximately 0 to +4 V into open circuit, 50Ω source impedance. Rise and fall times are typically 10 ns into 50Ω load. Sync is a square waveform during symmetrical outputs, rectangular waveform when SYMMETRY control is ON.

DC Offset

Front panel controlled between ±10 Vdc into open circuit, ±5 Vdc into 50Ω load. Peak voltage output (signal peak plus dc offset) is limited to ±10 V into open circuit, ±5 V into 50Ω load. DC offset and output waveform are attenuated proportionately by the attenuator.

VCG-VOLTAGE CONTROLLED GENERATOR

VCG Control Range

Up to 1000:1 frequency change with external voltage input. Upper frequency limited to maximum of selected range. Required external signal for full voltage control is 0 to 5 V with input impedance of 5 kΩ.

VCG Slew Rate

2% of range per μs.

VCG Linearity

±0.5% for 0.0003 Hz to 3 MHz.

TRIGGERED GENERATOR

Trigger Input

Trigger pulse is 1 V p-p to ±50 V; input impedance is 10 kΩ, 33 pF; minimum pulse width is 25 ns; maximum repetition rate is 20 MHz.

Start/Stop Point Adjustment

Triggered signal adjustable:
Approximately −90° to +90° to 3 MHz.
Approximately −90° to 0° for 3 MHz to 30 MHz.

OPERATIONAL MODES

Continuous

Operating as a standard VCG (voltage controlled generator), frequency output is determined by front panel control settings in conjunction with external control voltage at VCG IN.

Triggered

Only one complete cycle of output appears at 50Ω OUT connector for each pulse applied to TRIG IN connector (or press of MAN TRIG switch).

Gated

Same as triggered mode except that output oscillations continue for duration of gating signal applied to TRIG IN connector.

HORIZONTAL PRECISION

Dial Accuracy for Symmetrical Waveforms*

0.0003 Hz to 300 kHz ±(1% of setting +1% of full scale).
300 kHz to 30 MHz ±(3% of setting +2% of full scale).

Frequency Vernier

Electronic frequency vernier precision frequency adjustment is approximately 1% of range.

Time Symmetry*

±1.0% for 0.0003 Hz to 30 Hz.
±0.5% for 30 Hz to 300 kHz.

VERTICAL PRECISION

Sine Wave Frequency Response

Amplitude change with frequency less than:
0.1 dB to 300 kHz.
0.2 dB to 3 MHz.
2.5 dB to 30 MHz.

Step Attenuator Accuracy

±0.25 dB/10 dB step.

Stability*

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency, and dc offset.

Amplitude Symmetry

All symmetrical waveforms are symmetrical about ground within ±1% of amplitude range up to 3 MHz; e.g., within ±100 mV with output attenuator at 0 dB.

PURITY*

Sine Wave Distortion

Less than:
0.5% (typically 0.25%) for 10 Hz to 100 kHz.
1.0% for 0.0003 Hz to 3 MHz.
All harmonics at least 26 dB down for 3 MHz to 30 MHz.

Triangle Linearity

Greater than:
99% for 0.0003 Hz to 300 kHz.

Square Wave Rise and Fall Time

Less than 12 ns (typically 8 ns) when terminated into 50Ω load.

Square Wave Total Aberrations

Less than 5%.

Trapezoidal Rise and Fall Time

Ratio of period to rise or fall time is continuously variable from 2:1 (triangle) to greater than 100:1 and limited to 12 ns (maximum) rise and fall time.

ENVIRONMENTAL

All specifications listed are for 25°C ±5°C. For operation from 0°C to 55°C, derate all specifications by a factor of 2.

MECHANICAL

Dimensions

14½ in./36.8 cm wide, 5¼ in./13.3 cm high, 13½ in./34.3 cm deep.

Weight

12 lb/5.5 kg net, 19 lb/8.6 kg shipping.

Power

90 V to 110 V, 105 V to 125 V, 180 V to 220 V or 210 V to 250 V; 50 Hz to 400 Hz. Less than 50 watts.

Note: Specifications apply from 10% to 100% of a selected frequency range. Prices and specifications subject to change.

*SYMMETRY control OFF.

ORDER INFORMATION

Model 162—$845 (FOB San Diego)

MODEL 164 THIRTY MHz SWEEP GENERATOR

The Model 162 characteristics and specifications are applicable to the Model 164. In addition, the Model 164 has a sweep generator that provides these additional capabilities.

VERSATILITY

Sweep generator ramp and steps for continuous or discrete-step sweep; up or down sweeping. The swept signal may be triggered, gated, single stepped or swept-and-held. Main generator frequency may be swept as much as 1000:1.

Sweep/Step Range

Sweep/step time is selectable from 10 μs to 100 s in the following ranges:

100 s to 10 s	0.01 Hz to 0.1 Hz
10 s to 1 s	0.1 Hz to 1 Hz
1 s to 100 ms	1 Hz to 10 Hz
100 ms to 10 ms	10 Hz to 100 Hz
10 ms to 1 ms	100 Hz to 1 kHz
1 ms to 100 μs	1 kHz to 10 kHz
100 μs to 10 μs	10 kHz to 100 kHz

Sweep Output

SWEEP OUT connector provides a 0 to +5 V positive ramp from a 600Ω impedance source when SWEEP MODE is RAMP UP or RAMP DOWN, or 0 to +5 V stair step waveform in 10 equal steps when SWEEP MODE is STEP UP or STEP DOWN.

GCV Output

GCV OUT connector provides voltage proportional to main generator frequency from a 600Ω impedance source.

SWEEP MODES

Ramp Up

Main generator sweeps linearly from frequency set on front panel to a higher frequency determined by SWEEP WIDTH control at a rate set by SWEEP/STEP TIME control, then returns immediately to start frequency.

Ramp Down

Same as RAMP UP except frequency decreases.

Step Up

Same as RAMP UP except main generator frequency steps up in 10 equal steps.

Step Down

Same as RAMP UP except main generator frequency steps down in 10 equal steps.

MAIN GENERATOR OPERATIONAL MODES

Continuous Sweep

Main generator is repeatedly swept in one of the four sweep modes with start and stop frequencies set by the front panel controls.

Triggered Sweep

Main generator oscillates at the frequency set on the front panel. When triggered, it makes one sweep in the selected sweep mode and then returns to the front panel set frequency.

Sweep Hold

Same as triggered sweep except output frequency can be held at final sweep frequency after sweep.

Sweep Burst

Main generator output is a gated swept frequency for the duration of the gate. Between gate signals, output is a dc level.

Single Step

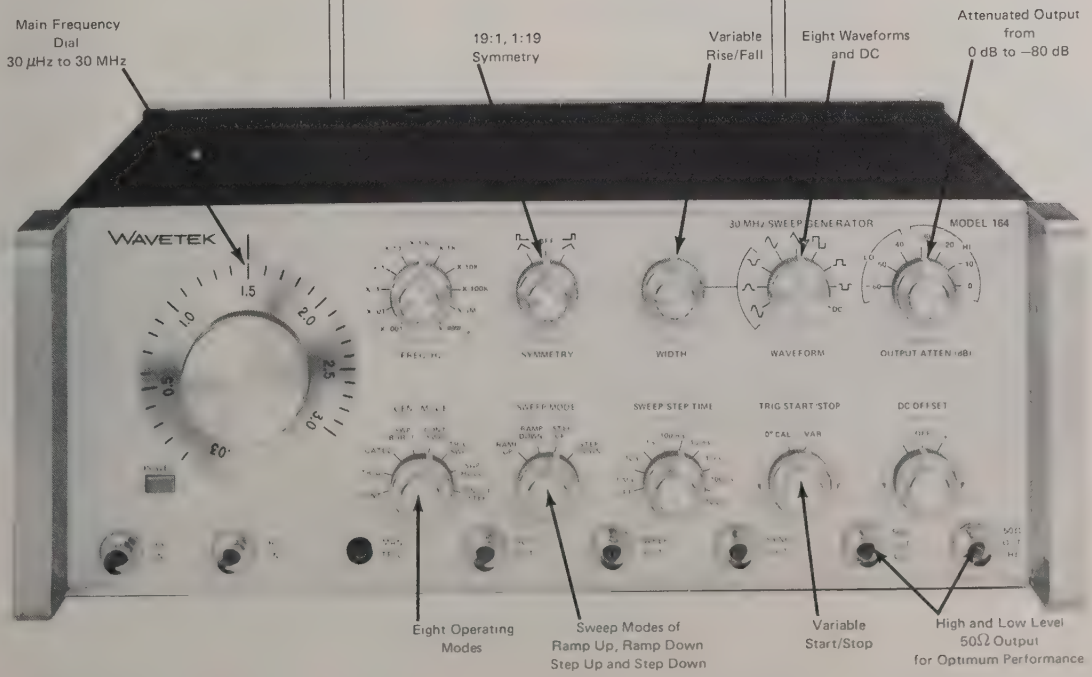
Main generator steps to next one of eleven frequency levels when triggered; eleventh trigger returns output to start frequency.

WEIGHT

13 lb/5.9 kg net, 20 lb/9 kg shipping.

ORDER INFORMATION

Model 164 — $995 (FOB San Diego)



SERIES 120 FUNCTION GENERATORS

Wavetek 120 Generator and Modules offer a wide range of signal generation capabilities in convenient modular form for systems applications. The modules can be used as voltage-to-frequency converters, fixed frequency oscillators, voltage controlled oscillators, sawtooth and swept sine wave generators, and triggered and tone burst signal sources to 100 kHz. The modules, as listed below, can be directly integrated into various systems or can be supplied on a single assembled printed circuit card.

SELECTION GUIDE

Module	Function
120-021	∿, ⊓, ◺, ⊔ Generator
120-022	∿ to ∿ Converter
120-023	Trigger for Module 120-021
120-024	15V Regulator

Card	Modules Featured
120-020-1	120-021, 120-024
120-020-2	120-021, 120-024, 120-022
120-020-3	120-021, 120-024, 120-022, 120-023

MODEL 120-021 GENERATOR MODULE

Simultaneous triangle ∿ and square ⊓ (or sawtooth ◺ and pulse ⊔). External resistor selection determines output waveform pair. Frequency determined by external range capacitor and applied control voltage. Fixed voltage gives a fixed frequency output; ramp voltage gives swep frequency output; sinusoidal voltage gives frequency modulated output.

Frequency Range

DC to 100 kHz. Actual range determined by use of high quality external capacitor. Operation of the generator with range capacitors less than 100 pf is not recommended.

Control Voltage

The control voltage must be supplied from a low impedance (less than 1Ω) source, and for normal operation must be between 100 mV and 5 V. The generator can operate with control voltages in an extended range of 10 m to 10 V.

Outputs

Square wave ⊓ (or pulse ⊓): 12 V p-p into open circuit from 1 kΩ source. Triangle wave ∧ (or sawtooth ◿): 3 V p-p, peak load current 3 mA maximum.

Stability

Short term: ±0.05% for 10 minutes.
Long term: ±0.25% for 24 hours.
For amplitude, and (+ 10 μV) for frequency in terms of operating point voltage.

Square Wave Rise and Fall Times

Less than 2 μs with 3 kΩ load.

Triangle Wave Linearity

Greater than 99%.

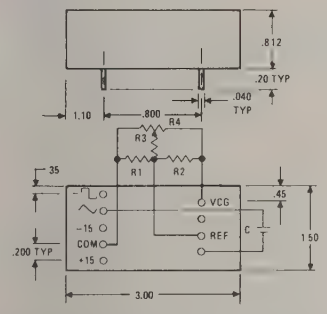
Temperature Effect

Less than 0.05% per degree C plus effects contributed by the range capacitor.

Power Requirements

±15 V, 30 mA.
Accuracy: 1%.
Regulation: 0.1%.
Ripple and Noise: <1 mV.
A 1% variation in ± 15-volt supplies is equivalent to <0.1% control voltage error.

Mechanical



MODEL 120-022 SINE CONVERTER

Converts triangle wave ∧ from generator to sine wave ∿.

Input

Triangle wave ∧ from 120-021 generator.

Output

Sine wave ∿ > 3 V rms capable of driving a 4 kΩ load.

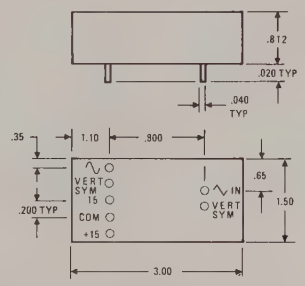
Sine Wave Distortion

10 Hz to 100 kHz: Less than 0.5%.

Power Requirements

±15 V, 20 mA.
Accuracy: 1%.
Regulation: 0.1%.
Ripple and Noise: < 1 mV.

Mechanical



MODEL 120-023 TRIGGER MODULE

Starts and stops the 120-021 generator with an external signal.

Trigger (Gate)

0 ±0.5 V inhibits the generator; +1 to +10 V enables. When the trigger signal is removed, the generator will complete any previously initiated cycle.

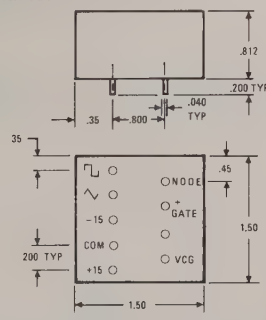
Generator Output When Inhibited

Triangle wave ∧ : 0 ± 100 mV
Square wave ⊓ : negative peak.

Power Requirements

± 15 V, 10 mA.
Accuracy: 1%.
Regulation: 0.1%.
Ripple and Noise: < 1 mV.

Mechanical



MODEL 120-024 REGULATOR MODULE

Provides both ±15V regulation from ± sources of 20 to 30 volts.

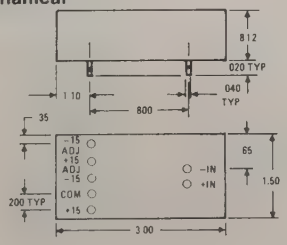
Output

±15V, 200 mA maximum.
Accuracy: 1%.
Regulation: 0.1%.
Ripple and Noise: <1 mV.

Power Requirement

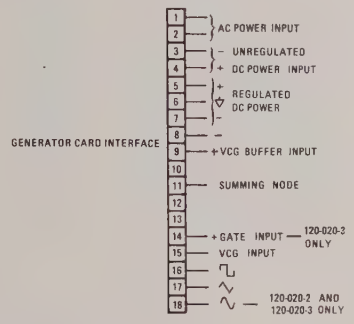
+ 25 ±5 V, − 25 ±5 V, 200 mA maximum.

Mechanical



CARD MOUNTED GENERATORS

Various generator configurations are mounted on a 4½ by 8-inch printed circuit card. The range capacitor and adjustment resistors are included, and the assembled generator is calibrated for operation in a particular frequency range. Pin connections for this card are shown below. The following configuration are available.



120-020-1 Generator Card

This includes the 120-021 generator module and 120-024 regulator for systems with unregulated + 20 to + 30 and − 20 to − 30 volts. At customer request, a 120 V or 240 Vac power supply will be substituted for the regulator. The range capacitor for the operating frequency range will be supplied to the user's specifications.

120-020-2 Generator Card

Same as above with the addition of sine wave capability.

120-020-3 Generator Card

Same as the 120-020-2 card with the addition of trigger capability.

ORDER INFORMATION
(FOB San Diego)

Module	1-9	10-99	100 up
120-021	$ 98	$ 89	$ 84
120-022	87	76	72
120-023	54	49	47
120-024	78	70	66
Card-Mounted Assembly			
120-020-1	$324	$292	$276
120-020-2	411	370	350
120-020-3	465	419	392

Note: When ordering card assembly, frequency range and either ac or dc input power must be specified.

MODEL 30 FUNCTION GENERATOR

The all new Wavetek Model 30 Function Generator is a battery operated, self-sweeping audio function generator of unusual value and small size. The Model 30 provides a complete audio signal source in an extremely compact, portable package. This low priced instrument has the waveform capability you normally find in function generators several times its price. There are three frequency ranges which give an overall frequency range of 2 Hz to 200 kHz. It also has internal linear and logarithmic sweep capability. In each range, the frequency may be varied from the maximum range value to one-thousandth of that value.

The operating modes are dial control of frequency, external voltage control of generator frequency (VCG) and fast, medium, and slow frequency sweep rate modes. The response to any of these modes of control is selectable to be either linear or logarithmic.

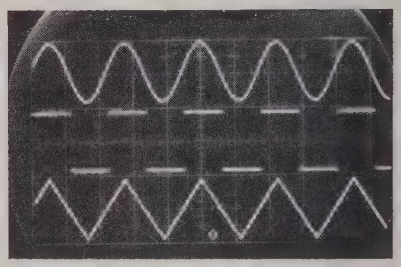
A sine wave output can be varied from 0 to over 1 V rms from a 600 ohm source at the front panel and is available at a rear auxiliary terminal but reduced by 40 dB.

A square wave output at the front panel is for oscilloscope synchronizing or driving logic circuits.

Rear panel terminals give sine wave, triangle wave, sweep sync, generator sync, horizontal drive (linear ramp and log ramp) signals and allow connection of external timing capacitors for the main generator and the ramp generator, control voltage input (VCG), and a battery charger input.

The battery supplied with the generator will power it for the equivalent of approximately one 8-hour day. As an option, a battery charger and a rechargeable battery are available for unrestricted line operation as well as battery charging. Overnight charge gives 3 hours of generator operation.

The hand-size, impact-resistant Model 30 is easily portable, and its battery power supply allows operation anywhere with complete line isolation.



Frequency Ranges

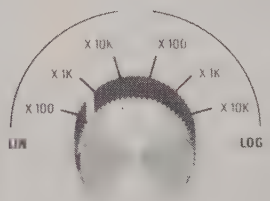
2 Hz to 2 kHz.
20 Hz to 20 kHz.
200 Hz to 200 kHz.
All ranges can be controlled in either linear or logarithmic response. For added frequency range, connections are provided for adding an external capacitor for unlimited down ranging.

Dial Accuracy

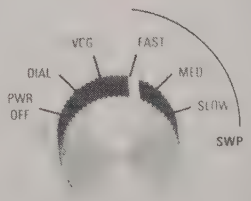
±2% of range to 20 kHz.

Variable Outputs

High Level Sine Wave: This front panel output is variable up to 1 V rms open circuit from 600Ω source. Distortion is less than 2% from 20 Hz to 20 kHz.

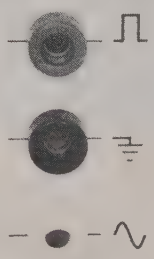


RANGE



MODE

AMPLITUDE



WAVETEK

Low Level Sine Wave: Varies with the high level sine wave, and is approximately 1% of high level output.

Fixed Outputs

Pulse: This front panel output provides a 50% duty cycle pulse output with nominal TTL levels of 0 V to +0.5 V (low) and +3 V to +4.5 V (high).

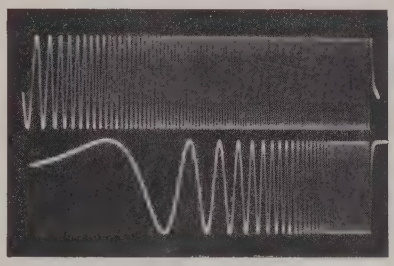
Triangle Wave: A rear panel output of approximately 1 V p-p, less than 2 mA peak current.

Generator Sync Out: Rear panel output in parallel with the front panel pulse output.

Operational Modes

Dial: The generator operates as a conventional oscillator with frequency selected by the front panel controls.

VCG: The generator operates as a Voltage Controlled Generator. The frequency is determined by the voltage applied to the rear panel VCG input and front panel selected range. Full scale frequency change requires approximately 1 volt input. Response is either linear or logarithmic selectable.



Sweep: The generator sweeps the full frequency range; for example, 20 Hz to 20 kHz when in the X 1K range. The sweep function is either linear or logarithmic. Approximate sweep times are:

Fast	2.5 ms
Medium	250 ms
Slow	25 s

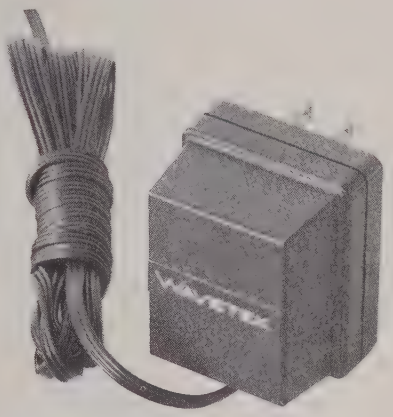
For further sweep versatility, external capacitors can be connected for unlimited increase of the sweep period.

Power Source

The generator is supplied with a conventional 9 V transistor battery (Mallory MN 1604 or equivalent). This will operate the generator for approximately a full eight hour day at maximum output.

Rechargeable Power Supply Option

The generator can be supplied with a rechargeable nickel-cadmium battery and charger circuit as an option. This option gives unlimited operation time when left connected to the line voltage and approximately three hours of battery operation when removed.



ORDER INFORMATION

The Wavetek Model 30	**$149.95**
Rechargeable Power Supply Option	**$ 25.00**

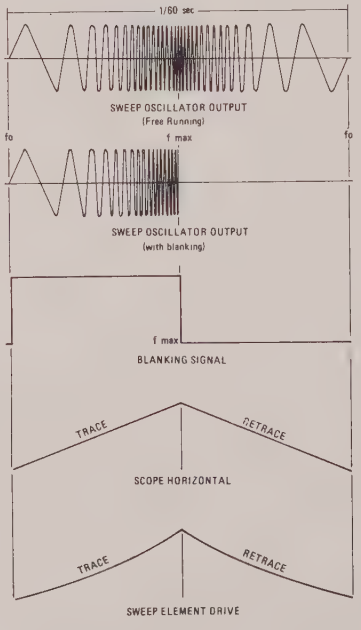
The Model 30 is kept in stock at the local Wavetek Sales and Service Centers throughout the world (a list is in the back of this catalog). Call your nearest Wavetek Representative for instant delivery of the Wavetek Model 30.

SWEEP/SIGNAL GENERATORS

The present day solid state sweep/signal generators have obsoleted the point-by-point method of determining the frequency response characteristics of high frequency (RF and microwave) components and systems. The speed, completeness and accuracy of obtaining response data has made Wavetek sweep/signal generators, in particular, indispensable instruments in both production test departments and engineering development laboratories. An examination of the following Wavetek sweep/signal generator features and specifications will help you select the precision instrument for your needs.

For a precision foundation upon which to build, Wavetek uses voltage tunable diodes in all of its standard general purpose sweepers and most of its TV sweep generators. Diodes are now available for use well up into the microwave region. The sweep element consists of a back-biased semiconductor junction whose capacity changes with the voltage applied to it. It is extremely stable and insensitive to temperature variations.

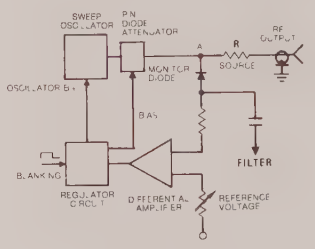
The typical output waveforms of a sweep signal generator are shown below. The generated frequency is increased from f_0 to f_{max} and back to f_0 as voltage is applied to the oscillator diodes. This process corresponds to one cycle of the sweep rate. The example shown pertains to a 60 Hz sweep rate; however, in most general purpose applications variable rates are used.



Typical Sweep Generator Output

Since it is usually desirable to sweep upwards only (from f_0 to f_{max}) a square wave is generated to blank off the oscillator during retrace (from f_{max} to f_0). Also, because most response patterns are to be observed on an oscilloscope, a triangular waveform to drive the oscilloscope horizontal amplifier must be generated in the sweeper. Both the square wave and triangular wave must be synchronized with the sweeping element.

Wavetek takes particular pride in the flatness, or constant level, of the RF output signal over our generator frequency ranges. Here is a simplified output circuit of a standard Wavetek sweeper. The output from

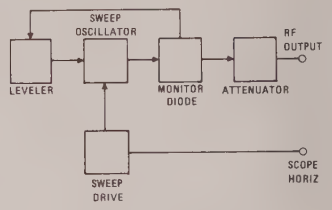


Output Circuits

the oscillator is sampled by the monitor diode at point "A" and in turn connected to the input of a differential amplifier whose other input is selected from a reference voltage. The error signal controls the bias to the PIN diode attenuator. Hence, a constant voltage at "A" (and a constant RF output power level) is maintained. The reference voltage is a variable which can be adjusted to calibrate the RF output.

The blanking signal controls the regulator circuit, removing the oscillator B+ during retrace. Point "A" can be considered an ac generator with a zero source impedance. The addition of a 50 ohm resistor between point "A" and the RF output connector presents a 50 ohm source impedance looking back. Similarly, the addition of a 75 ohm resistor would present a 75 ohm source impedance.

A simplified block diagram of the standard Wavetek sweep generator is shown below.

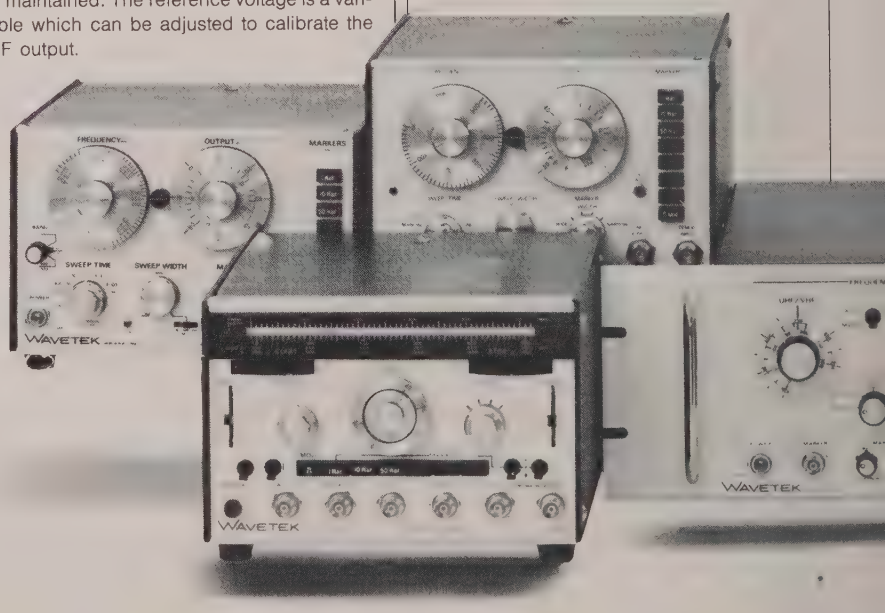


Sweep Generator

Some of its more important operating parameters are discussed in the following paragraphs.

FREQUENCY RANGE AND SWEEP WIDTH

Frequency range is defined as the low and high frequency limits attainable in a particular sweep generator. The limits correspond to the minimum and maximum range that can be attained by tuning both the center frequency and sweep width controls. For convenient measurement techniques, the sweep width of a particular unit should always be greater than the maximum required test bandwidth. Sweep width is usually expressed in either frequency limits or as a percentage of the center frequency, e.g.,



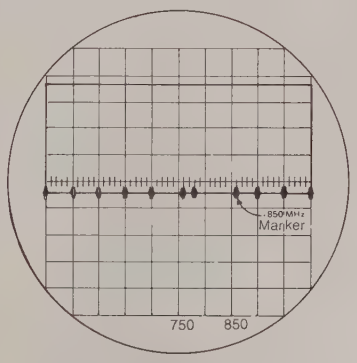
200 MHz to 400 MHz or ±33% of the 300 MHz center frequency. The Model 2001 has a calibrated sweep width control whereas the Series 1000 and Models 1801A and 2000 have uncalibrated controls.

FLATNESS

Flatness is one of the most important specifications of a sweeper because it directly affects measurement accuracy. It is normally stated in terms of dB and indicates the maximum change in output power over the sweep width being utilized. Since there are several ways to measure flatness (positive or negative polarity detectors, power meters, etc.) care must be taken when comparing the flatness specifications of different units. The test and calibration sections of every general-purpose sweep generator instruction manual completely defines the method employed in measuring this key parameter.

FREQUENCY LINEARITY

The most meaningful method of specifying frequency linearity is as a percentage deviation from a straight-line function. A typical method of measuring frequency linearity involves the use of harmonic markers, found in most general purpose sweeper requirements. Here is an example of nonlinearity in the response of a 500 to 1000 MHz signal displayed on an oscilloscope with 50 MHz harmonic markers added to the detected output. When linearity is perfect, each marker



Marker Linearity Detection

falls directly on top of a graticule line. Since linearity specifications are defined differently among manufacturers (percentage of sweep width, percentage of center frequency, percentage of highest frequency, etc.), care must be taken when equating or comparing sweeper specifications.

FREQUENCY DIAL RESOLUTION AND ACCURACY

The frequency dial should indicate the center or end frequencies of the CW output frequency accurately and be repeatable over a wide range of environmental conditions. Also, the frequency resolution should be significantly better than the dial accuracy. This is true in most sweepers, since the markers (accurate to ±0.005%) can be used to identify frequency. Hence a dial accuracy of 1% is considered quite adequate in satisfying the vast majority of sweeper applications.

SWEEP RATE

General purpose sweep generators are normally equipped with variable sweep rate capability. This is necessary to ensure that the sweep-rate, sweep-width combination employed is not too large for the time constant of the circuit under test. The feature is particularly important if multiple-tuned circuits with sharp skirt selectivity are being measured. The sweep rate should always be set as low as is practical and well below the point at which peak amplitude changes are noticeable.

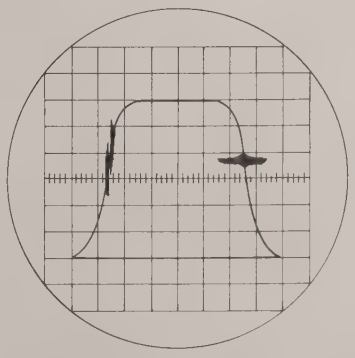
FREQUENCY STABILITY

The frequency stability error is covered by the dial accuracy specification. Temperature, humidity, aging of components, power supply variation and mechanical stresses all affect the output frequency. Stability and sweep width are constantly conflicting requirements in that one requires an oscillator insensitive to change whereas the other requires an oscillator extremely sensitive to change. Most sweep generators are limited in stability by power supply variations. Extremely short-term stability is defined as residual FM and can be measured with a deviation meter, calibrated frequency discriminator or a spectrum analyzer.

MARKERS

There are many types of frequency marker systems used in presently available sweepers. By far, the most accurate type of marker is a birdy indication, since it is the result of the zero beat of a crystal-controlled signal mixing with a sample of the sweep.

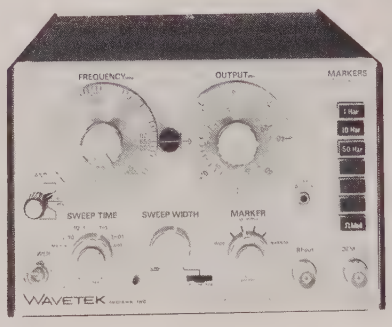
In the Wavetek general purpose sweepers, the width of the marker may be varied by filters in the marker circuit or the sweep width control associated with the marker. If the birdy appears on a flat portion of a response curve it is easily discernible. If, however, it is on a steep slope of a response it is sometimes difficult to find. Most Wavetek sweepers incorporate a tilt circuit whereby the birdy can be added to the horizontal axis of the oscilloscope as shown and can be easily seen.

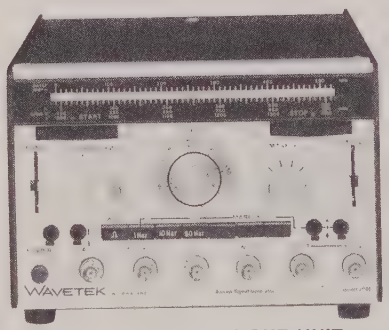


Birdy Marker with Tilt Control

For maximum effectiveness of this marker tilt capability, the oscilloscope must have balanced vertical and horizontal input amplifiers and a bandwidth of approximately 500 kHz.

MODELS 2000/2001 SWEEP/SIGNAL GENERATORS





- **1 MHz TO 1400 MHz IN ONE UNIT**
- **IDEAL FOR BOTH BROAD AND NARROW SWEEP APPLICATIONS**
- **CALIBRATED RF OUTPUT SYSTEM**
- **MANUAL, TRIGGERED, OR RECURRING SWEEP MODE**
- **EXCELLENT FLATNESS AND DISPLAY LINEARITY**

The compact Models 2000 and 2001 Sweep/Signal Generators offer versatility and an exceptionally wide frequency range (1 MHz to 1400 MHz) in a ruggedized, solid-state instrument. Because of their unique adaptability, these instruments can be utilized in engineering laboratory applications as well as for production test requirements. Complete remote programming and external AM or FM modulation is possible through the use of complete electronic tuning and PIN diode leveling and attenuation.

The three frequency bands (1 MHz to 500 MHz, 450 MHz to 950 MHz, and 900 MHz to 1400 MHz) are PIN diode switched and may be swept from CW to full 500 MHz sweep width. The units may be line locked or swept at rates of 50 sweeps per second to 1 sweep every 100 seconds. Manual and triggered modes are also provided.

The Model 2001 provides three operational modes. In the start/stop (S/S) mode, the START dial sets the start-sweep frequency and the STOP dial sets the stop-sweep frequency. In the ΔF mode, the START dial sets the center frequency and the STOP dial sets the sweep width (from 200 kHz to 500 MHz). In the CW mode, the START dial sets the center frequency and the STOP dial is disabled. A 100% duty cycle is provided in the CW mode by removing the oscillator blanking. The Model 2000 provides for ΔF and CW operation only.

The high output (10 mW) is internally leveled to within ±0.5 dB over the entire range and provisions for external leveling are provided. The RF output system is calibrated from +10 dBm to −80 dBm in 1 dB intervals. A 70 dB attenuator provides incremental 10 dB steps, while a continuously variable PIN diode attenuator adds an additional 0 dB to 20 dB.

The instruments include a complete crystal-controlled birdy-type marker system incorporating several features. The marker width may be selected, in four steps, from approximately 15 kHz to 400 kHz, providing a useable marker for wide or narrow band operation. For steep slopes, the markers may be tilted 90° from vertical. A leveled sweep sample is used to produce the markers, so that they are all at the same amplitude. For example, with the 0.1 MHz harmonic, 14,000 markers result from 1 MHz to 1400 MHz, all at the same amplitude.

Provisions are made for a combination of up to six plug-in marker modules. The markers may be at single discrete frequencies (A-1 Option) or at harmonic type (comb) intervals (A-2 Option). Each marker has an individual on-off switch engraved with the marker frequency.

Other available options include pen lift and 1 kHz square wave modulation for low level recovery applications. 75 ohm output impedance (calibrated from +57 dBmV to −33 dBmV) is also available at no additional cost.

The unit will interface with various network analyzers and attenuation test sets available.

RF FREQUENCY

Frequency Range
1 MHz to 500 MHz.
450 MHz to 950 MHz.
900 MHz to 1400 MHz.

Dial Calibration
10 MHz/div.

Accuracy

10 MHz	Band 1
2% of selected frequency	Bands 2, 3

Sweep Width
200 kHz to 500 MHz.

Uncalibrated	2000
Calibrated in 10 MHz/div	2001

Operating Modes

ΔF and CW	2000
ΔF, CW and Start/Stop	2001

Display Linearity
2%.

Spurious Signals
−30 dB.

Residual FM
Less than 15 kHz.

Drift
Less than:
100 kHz for 5 minutes.
2 MHz for 8 hours.
(At a constant temperature after ½ hour warm-up.)

Blanking
Blanking of RF output during retrace. Removed for CW operation.

RF OUTPUT

Impedance
50 ohms (75 ohms available).

Output Amplitude
+10 dBm maximum.

Output Flatness
±0.5 dB.

Attenuation
Continuously adjustable from +10 dBm to −80 dBm. 70 dB in 10 dB steps plus a 20 dB PIN diode attenuator calibrated in 1 dB increments.

Accuracy
±0.5 dB to 500 MHz.
±1 dB to 1000 MHz.
±2 dB to 1400 MHz.

SWEEP MODES
Recurring, single sweep, external trigger, manual, and line-lock.

Sweep Time
Continuously variable from less than 10 ms to greater than 100 s, in 4 decade steps, plus vernier.

Horizontal Output
16 V p-p symmetrical about ground (0 V to +10 V available upon request).

MARKERS
Provisions for up to 6 crystal-controlled plug-in birdy bypass markers, plus external marker input. Markers may be either discrete frequency (Option A-1) or harmonic type (Option A-2).

Accuracy
0.005%.

Width
Adjustable from approximately 15 kHz to 400 kHz in 4 steps.

Amplitude
Adjustable from approximately 1 mV to 1 V p-p.
15 mV to 12 V available, Model 2001.

Marker Tilt
Adjustable from vertical to approximately 90°.

External Marker
BNC input accepts CW signal for conversion to a birdy marker. Input level must be at least 100 mV into 50Ω.

Recorder Processing
Internal switch removes negative portion of birdy markers for use with X-Y recorders.

REMOTE PROGRAMMING
Rear mounted jack provides necessary connections for remote control of center frequency, sweep width, and 20 dB vernier output control.

External FM
±16 V results in full deviation at rates up to 4 kHz. With reduced deviation and linearity, modulation rates to 100 kHz are possible.

External AM
0 V to −18 V signals are applied to 20 dB vernier output attenuator. With average voltage set to mid-range, modulation possible to 50 kHz.

External Leveling
External negative signal (ALC) between 0.2 V and 2 V may be used to level RF output.

MECHANICAL

Dimensions
8¼ in./20.9 cm wide, 5¼ in./13.3 cm high, 12 in./30.5 cm deep.

Weight
20 lb/9.1 kg net, 25 lb/11.4 kg shipping.

Power
115/230 V ±10% (available for 100/200 V at no extra cost); 50/60 Hz. Approximately 20 watts.

ORDER INFORMATION
(FOB Beech Grove)

Model 2000 **$1375**

Model 2001 **$1695**

Options

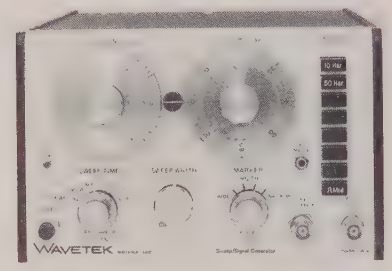
A-1 **$50 each**
Single frequency markers from 1 MHz to 1400 MHz (specify frequency).

A-2 **$60 each**
Harmonic type (comb) frequency markers at 1.0, 5.0, 10.0, or 50.0 MHz (specify frequency).
Note: Harmonic type 0.1 MHz markers (with associated 1.0 MHz markers) available at $150. Other frequencies available on special order.

A-4 **$50**
1 kHz square wave generator plug-in module for 100% amplitude modulation of RF output for low level recovery applications.

A-5 **$25**
Pen Lift.

SERIES 1000 SWEEP/SIGNAL GENERATORS



- **WIDE BAND, SOLID-STATE OPERATION**
- **CALIBRATED RF OUTPUT SYSTEM**
- **IDEAL FOR ENGINEERING LAB OR PRODUCTION TEST**
- **AVAILABLE IN 50 OHMS OR 75 OHMS**
- **ANALOG PROGRAMMING OF RF OUTPUT AND FREQUENCY**

The 1000 Series Sweep/Signal Generators are a group of four wide band, general purpose sweepers, covering the frequency range from 0.5 MHz to 1.4 GHz. Each model features solid-state design, PIN diode leveling, and attenuation, and provides for external amplitude and frequency modulation.

The specifications, applications, and prices of these high quality sweep generators are virtually unequaled in the industry. All are usable as signal generators with such features as AM and FM modulation, excellent dial accuracy and resolution, and calibrated output. Each instrument is a completely programmable signal source.

Low residual FM and the excellent oscillator stability in the 1000 Series provide a usable signal source when in CW operation. When using any of these instruments as a signal generator, a vernier ratio of 50 to 1 over the main tuning dial is included. For short term accuracy, the 0.005% accurate marker system may be used as a crystal calibrator.

Up to seven plug-in marker modules, each with an individual on-off switch, may be added to the marker system. The markers may be at single discrete frequencies or harmonically related intervals (comb type). For example, when using the 0.1 MHz harmonic in the Model 1004 (500 MHz to 1000 MHz), 5000 markers occur, one each 100 kHz. A unique marker circuit provides constant amplitude of each birdy indication. For optimum wide or narrow band operation, marker width is adjustable from 15 kHz to 400 kHz.

The four models in this series are the 1001A, 1002, 1004, and 1005. When specifications differ, the model numbers are noted.

RF FREQUENCY

Frequency Range

0.5 MHz to 300 MHz	1001A
1.0 MHz to 500 MHz	1002
500 MHz to 1000 MHz	1004
700 MHz to 1400 MHz	1005

Dial Calibration

10 MHz/div	1001A, 1002, 1004
20 MHz/div	1005

Vernier Dial
Expands main frequency dial ±1% of full scale frequency (50:1 increase in resolution).

Sweep Width

0.2 MHz to 300 MHz	1001A
0.2 MHz to 500 MHz	1002
0.4 MHz to 500 MHz	1004
0.5 MHz to 700 MHz	1005

Operating Modes
ΔF and CW.

Display Linearity
2%.

Spurious Signals
−30 dB (10 MHz to 1400 MHz).

Residual FM
Less than:

10 kHz	1004
15 kHz	1001A, 1002
20 kHz	1005

Drift
Less than:
100 kHz for 5 minutes.
2 MHz for 8 hours.
(At a constant temperature after ½ hour warm-up.)

Blanking
RF output off during retrace providing a true zero base line. Blanking removed for CW operation.

RF OUTPUT

Impedance
50 ohms (75 ohms available).

Output Amplitude

+10 dBm, 0.7 V rms	1004, 1005
+13 dBm, 1.0 V rms	1001A, 1002

Output Flatness
Over full range:

±0.25 dB	1001A, 1002, 1004
±0.50 dB	1005

Attenuation
90 dB; 70 dB in 10 dB steps plus 20 dB PIN diode attenuator calibrated in 1 dB increments.

Accuracy
±0.5 dB to 500 MHz.
±1.0 dB to 1000 MHz.
±2.0 dB to 1400 MHz.

SWEEP MODES

Repetitive, internally triggered single sweep, manual, line lock.

Sweep Time
Continuously variable from less than 10 ms to greater than 100 s in 4 decade steps, plus vernier.

Horizontal Output
16 V p-p symmetrical about ground (0 V to +10 V available upon request).

MARKERS

Provisions for up to 7 crystal-controlled plug-in birdy bypass markers, plus rear panel external marker input. Markers may be either single frequency (Option A-1) or harmonic type (Option A-2).

Accuracy
0.005%.

Width
Adjustable from approximately 15 kHz to 400 kHz in 4 steps.

Amplitude
Adjustable from approximately 1 mV to 1 V p-p.

Marker Tilt
Adjustable from vertical to approximately 90°.

External Marker
Rear panel BNC input accepts CW signal for conversion to a birdy marker. Input level must be at least 100 mV into 50Ω.

Recorder Processing
Internal switch removes negative portion of birdy markers for use with X-Y recorders.

REMOTE PROGRAMMING

Rear mounted jack provides necessary connections for remote control of center frequency, sweep width, and 20 dB vernier output control.

External FM
±16 V results in full deviation at rates up to 4 kHz. With reduced deviation and linearity, modulation rates to 100 kHz are possible.

External AM
0 V to −18 V signals are applied to 20 dB vernier output attenuator. With average voltage set to mid-range, 100% modulation obtainable to 1 kHz, 40% modulation to 40 kHz.

External Leveling
External negative signal (ALC) between 0.2 V and 2 V may be used to level RF output.

MECHANICAL

Dimensions
8¼ in./20.9 cm wide, 5¼ in./13.3 cm high, 12 in./30.5 cm deep.

Weight
15 lb/6.8 kg net, 20 lb/9.1 kg shipping.

Power
115/230 V ±10% (available for 100/200 V at no extra cost); 50/60 Hz. Approximately 20 watts.

ORDER INFORMATION

(FOB Beech Grove)

Model 1001A, 1004, or 1005	**$ 995**
Model 1002	**$1095**

Options

A-1 **$50 each**
Single frequency markers from 1 MHz to 1400 MHz (specify frequency).

A-2 **$60 each**
Harmonic type (comb) frequency markers at 1.0, 5.0, 10.0, or 50 MHz (specify frequency).
Note: Harmonic type 0.1 MHz markers (with associated 1.0 MHz markers) available at $150. Other frequencies available on special order.

A-4 **$50**
1 kHz square wave generator plug-in module for 100% amplitude modulation of RF output for low level recovery applications.

A-5 **$25**
Pen Lift.

MODEL 1801A SWEEP/SIGNAL GENERATOR

- **COVERS COMPLETE CATV FREQUENCY RANGE**
- **75 OHM CALIBRATED OUTPUT**
- **CRYSTAL CONTROLLED MARKERS**
- **EXCELLENT FLATNESS AND LINEARITY**
- **SIMULTANEOUS SWEEP FEATURES**

The solid-state Wavetek Model 1801A Sweep/Signal Generator provides features and options ideally suited for the manufacturer, installer, and operator of CATV systems.

The frequency range of 1 MHz to 500 MHz, and the optional additional high band (450 MHz to 950 MHz), adequately cover the bands now being used as well as those of the future. The instrument will sweep each band in its entirety, or sweep width may be continuously reduced to CW operation.

The ultra flat 75 ohm output system is calibrated from +57 dBmV to −33 dBmV. 20 dB of the total attenuator is a continuously variable PIN diode attenuator. A three position reference switch, in parallel with this attenuator, will increase or decrease the output by ±0.5 dB. This greatly aids in flatness measurements by providing an accurate, rapid calibration reference.

Other features include a built-in RF detector, internal and external leveling, and a complete crystal-controlled birdy marker system which may be used to internally modulate the RF signal. A selection of marker widths for wide band or narrow band operation is also provided.

The instrument will sweep at line frequency or as slow as 1 sweep in 100 seconds. In addition, a special sweep rate position facilitates testing of operating CATV systems with minimum subscriber interference. The sweep time of this position is adjustable from 1 to 10 seconds.

RF FREQUENCY

Frequency Range
1 MHz to 500 MHz.
450 MHz to 950 MHz (optional).

Dial Calibration
10 MHz/div with ±5 MHz vernier.

Accuracy
10 MHz or 2% of selected frequency (whichever is greater).

Sweep Width
200 kHz to 500 MHz.

Display Linearity
2%.

Spurious Signals
−30 dB (−35 dB minimum available on special order).

Residual FM
Less than 15 kHz.

Drift
Less than:
100 kHz for 5 minutes.
2 MHz for 8 hours.
(At a constant temperature after ½ hour warm-up.)

Blanking
Blanking of RF output during retrace. Removed for CW operation.

RF OUTPUT

Impedance
75 ohms.

Output Amplitude
+57 dBmV, 0.7 V rms, maximum.

Output Flatness
±0.25 dB for 1 MHz to 500 MHz.

Attenuation
Continuously adjustable from +57 dBmV to −33 dBmV. 70 dB in 10 dB steps plus a 20 dB PIN diode attenuator calibrated in 1 dB increments.

Accuracy
±0.5 dB to 500 MHz.
±1.0 dB to 950 MHz.

Reference Attenuator
Internally adjustable from 0 dB to 0.5 dB above and below output level.

SWEEP MODES

Recurring, single sweep, external trigger, manual, and line-lock.

Sweep Time
Continuously variable from 10 ms to 100 ms and from 1 s to 100 s, plus a special variable 1 ms to 10 ms sweep time range with an associated variable 1 s to 10 s repetition rate for testing of operating CATV systems.

MARKERS

Provisions for up to 6 crystal-controlled, plug-in birdy bypass markers, plus rear panel external marker input. Markers may be either single frequency (Option A-1) or harmonic type (Option A-2).

Accuracy
0.005%.

Width
Adjustable from approximately 15 kHz to 400 kHz in 4 steps.

Amplitude
Adjustable from approximately 1 mV to 1 V p-p.
Note: Markers may be transmitted with RF signal.

REMOTE PROGRAMMING

Rear mounted jack provides necessary connections for remote control of center frequency, sweep width, and 20 dB vernier output control.

External FM
±16 V results in full deviation at rates up to 4 kHz. With reduced deviation and linearity, modulation rates to 100 kHz are possible.

External AM
0 V to −18 V signals are applied to 20 dB vernier output attenuator. With average voltage set to mid-range, modulation possible to 50 kHz.

External Leveling
External negative signal (ALC) between 0.2 V and 2 V may be used to level RF output.

MECHANICAL

Dimensions
8¼ in./20.9 cm wide, 5¼ in./13.3 cm high, 12 in./30.5 cm deep.

Weight
20 lb/9.1 kg net, 25 lb/11.4 kg shipping.

Power
115/230 V ±10% (available for 100/200 V at no extra cost); 50/60 Hz. Approximately 20 watts.

ORDER INFORMATION

(FOB Beech Grove)

Model 1801A

1 to 500 MHz	**$1245**
1 to 950 MHz, with both bands	**$1445**

Options

A-1 **$50 each**
Single frequency markers from 1 MHz to 950 MHz (specify frequency).

A-2 **$60 each**
Harmonic type (comb) frequency markers at 1.0, 5.0, 10.0, or 50.0 MHz (specify frequency).

A-4 **$50**
1 kHz square wave generator plug-in module for 100% amplitude modulation of RF output for low level recovery applications.

A-5 **$25**
Pen Lift.

SERIES 1312 SWEEP/MARKER GENERATORS

- **IDEAL FOR PRODUCTION TEST APPLICATIONS**
- **GENERATES FIXED FREQUENCY BANDS IN THE 4 MHz TO 250 MHz RANGE**
- **1 VOLT RMS OUTPUT**
- **FULL OR PARTIAL SWEEPING OF SELECTED BANDS**
- **USE FOR IF ALIGNMENT**

The Series 1312 Sweep/Marker Generators are versatile, solid-state instruments that generate fixed frequency bands in the 4 MHz to 250 MHz range. These bands can be electronically tuned and fully, or partially, electronically swept over the bandwidths indicated. The sweep/marker generators also provide crystal-controlled, pulse-type markers with frequencies easily changeable by substitution of plug-in crystals. The use of modular plug-in construction in these instruments allows maximum flexibility for factory or field modifications. Series 1312 instruments are ideal for production-line applications because the user pays for only the signals, markers, and features needed.

Standard center frequencies are available in the sweep generator section at 4.5 MHz, 5.5 MHz, 10.7 MHz, 11.5 MHz and 98 MHz. Corresponding frequency bandwidths are 4 MHz to 5 MHz, 5 MHz to 6 MHz, 9.7 MHz to 11.7 MHz, 10.5 MHz to 12.5 MHz, and 86 MHz to 110 MHz. Other bands, either wide or narrow, are available for military, fire, forestry, highway, industrial, land transportation, citizen radio, common carrier, flight-test telemetry, maritime, amateur radio, and scientific frequency bands over the 4 MHz to 250 MHz range.

The RF output of the Series 1312 instruments is 1 volt rms with an output impedance of 75 ohms (50 ohm output impedance available as option). The center frequency and sweep width are controlled by front panel potentiometers that permit full or partial sweeping of the bandwidths ordered. Front panel switches permit six fixed steps of attenuation and an electronic variable attenuator can be used to reduce the signal 30 dB for an overall attenuation capability of 109 dB. Center frequency, sweep width, and vernier attenuation may be programmed or remotely controlled.

The Series 1312 instruments provide up to five crystal-controlled, pulse-type markers, each controlled by individual front panel switches. Marker amplitude is adjustable from 0 volt to over 30 volts. The user may select either positive or negative marker polarity to allow Z-axis modulation of the associated oscilloscope for intensification or blanking of the electron trace. The markers may also be added to the oscilloscope vertical or horizontal input, depending on the presentation desired. Marker frequency can be changed by simple substitution of crystals with no further modification or tuning adjustments.

Kits are available for 19 inch rack mounting, or any two instruments may be mounted side-by-side in a 5¼ inch by 19 inch space. This dual rack mounting is ideal for in-plant distribution systems since an operating unit and one spare occupy only 5¼ inches of vertical rack space.

The Series 1312 generators include Models 1312-1, 1312-2, 1312-3, 1312-4, and 1312-9. When specifications differ, the model numbers are noted.

RF FREQUENCY

Frequency Range

Center frequency range and maximum sweep width:

4 MHz to 5 MHz	1312-1
5 MHz to 6 MHz	1312-2
9.7 MHz to 11.7 MHz	1312-3
10.5 MHz to 12.5 MHz	1312-4
86 MHz to 110 MHz	1312-9

Note: Other frequency ranges available on special order.

Display Linearity

4% of maximum sweep width.

Harmonic Content

At least 30 dB below fundamental output.

Blanking

RF output off during retrace providing a true zero base line.

RF OUTPUT

Impedance

75 ohms (50 ohms available).

Output Amplitude

1 V rms (0.5 V rms for 1312-9).

Output Flatness

±0.25 dB over maximum sweep width.

Attenuation

109 dB total (99 dB for 1312-9). Steps of 3, 6, 10, 20, 20, and 20 dB (accuracy ±0.5 dB per step). Vernier, 0 to 30 dB, uncalibrated (0 to 20 dB for 1312-9).

HORIZONTAL OUTPUT

16 V p-p, triangular waveform.

MARKERS

Five crystal-controlled (customer specify).

Accuracy

0.01% (measured from pulse leading edge).

Amplitude

0 V to over 30 V (rear panel amplitude control). May be wired to shut off sweep oscillator (internal modulation).

Marker Polarity

Positive or negative (selected by rear panel switch).

MECHANICAL

Dimensions

5¼ in./13.3 cm high, 8¼ in./20.9 cm wide, 13¾ in./34.9 cm deep.

Weight

14 lb/6.4 kg net, 19 lb/8.6 kg shipping.

Power

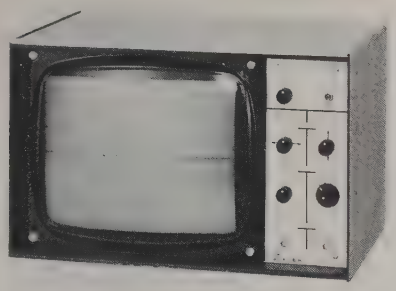
115/230 V ±10%; 50/60 Hz. Approximately 20 watts.

ORDER INFORMATION

(FOB Beech Grove)

Model 1312-1, 2, 3, 4, or 9	**$695**
Crystal Markers (up to five)	**$15 each**

MODEL 1901A X-Y DISPLAY OSCILLOSCOPE



- **LARGE 12 INCH DIAGONAL CRT**
- **1 mV/DIVISION SENSITIVITY**
- **BRIGHT, WELL FOCUSED TRACE**
- **IDEAL FOR PRODUCTION TEST APPLICATIONS**

The Wavetek Model 1901A solid-state X-Y Display Oscilloscope incorporates an extremely stable, low noise, vertical amplifier with sensitivities from 1 mV per division making it an ideal instrument for measuring frequency response in conjunction with available sweep/signal generators.

The 9 kV accelerating potential provides a bright, well focused, narrow trace on the large, easy to read, 12 inch cathode ray tube. Two intensity controls are provided, one for the beam itself and one for an intensity marker. This allows the trace and intensity spots to be individually adjusted for sharpness and brightness.

In the event of no horizontal input, the trace is automatically blanked off, preventing burnout of the CRT phosphor. The unit also has a rear panel vertical polarity reversal switch.

In most sweep test setups, internally generated discrete or harmonic frequency markers are added to the detected RF output of the sweeper and the resulting response curve displayed on a scope. In some measurement applications, it is desirable to add the markers directly to the scope rather than to the detected RF output. The Model 1901A incorporates a built-in marker adder for this purpose.

Standard units are supplied with P1 phosphor tubes and molded graticuled faceplates to minimize parallax. Units with P4 or P7 phosphor tubes and molded clear faceplates are optionally available. Standard 19 inch rack mounting kits can be provided.

DISPLAY

CRT
12 inch diagonal (30 cm).

Phosphor
P1 (medium persistence).
Note: P4 (medium short persistence) and P7 (long persistence) available as options.

Graticule
Molded plastic, 1.5 cm/div, 12 vertical, 16 horizontal.

Deflection
Magnetic.

Acceleration Voltage
9 kV nominal.

VERTICAL

Sensitivity
4 position step attenuator for 1 mV, 10 mV, 100 mV, and 1 V/div; continuously variable vernier between steps.

Impedance
374 kΩ.

Bandwidth
DC to 15 kHz (10 div amplitude).

Coupling
Switchable ac-dc (when ac coupled, maximum dc voltage plus ac peak not to exceed 200 V).

Linearity
5% (center 10 div).

Input Connector
BNC, front panel.

Drift
Typically less than ½ div for 8 hours (at a constant temperature after ½ hour warm-up).

Polarity
Rear panel switch for inversion of vertical signal.

HORIZONTAL

Sensitivity
Continuously adjustable from 0.1 V/div to over 10 V/div.

Impedance
Greater than 320 kΩ.

Bandwidth
DC to 1.5 kHz (14 div amplitude).

Coupling
Switchable ac-dc (when ac coupled, max dc voltage plus ac peak not to exceed 200 V).

Linearity
3% (16 div).

Input Connector
BNC, front panel.

Drift
Typically less than ½ div for 8 hours (at a constant temperature after ½ hour warm-up).

Protection Circuit
Prevents burnout of CRT by blanking the beam when horizontal signal is less than approximately 4 div (60 Hz rate). When operating at slower rate, or for servicing, a rear panel switch can be used to eliminate the protection circuit.

INTENSITY MODULATION (Z AXIS)

Sensitivity
±2 V pulse will produce a bright spot on the display.

Impedance
10 kΩ.

Intensity Adjustment
Separate rear panel control adjusts intensity of Z input, independent of front panel intensity control.

Input Connector
BNC, rear panel.

MARKER ADDER

Input Signal
Pulse or birdy.

Sensitivity (Max)
Typically 0.5 V/div (continuously adjustable with rear panel control).

Polarity
Rear panel switch provides polarity reversal.

Input Impedance
Approximately 15 kΩ.

ENVIRONMENTAL

+10°C to +50°C.

MECHANICAL

Dimensions
16-1/2 in./41.9 cm wide, 10-5/16 in./26.2 cm high, 14-1/4 in./36.2 cm deep.

Weight
26 lb/11.8 kg net, 35 lb/15.9 kg shipping.

Power
115/230 V ±10%; 50/60 Hz. Approximately 75 watts.

ORDER INFORMATION

(FOB Beech Grove)

Model 1901A	**$475**
Options	
A. P4 phosphor	**$10**
B. P7 phosphor	**$30**
C. Clear faceplate (no graticule)	**No Charge**
Accessories	
Faceplate (either clear or graticule)	**$10**
Amber filter (normally used with P7 phosphor)	**$10**
Rack mount kit	**$5**

MODEL 3000 SIGNAL GENERATOR

- **1 MHz to 520 MHz Frequency Range with 1 kHz Resolution**
- **Overall Frequency Accuracy of 0.001%**
- **Phase-lock Stability**
- **Built-in Frequency Programmability**
- **Calibrated Output from +13 dBm to −137 dBm**
- **Internal and External AM/FM Capability**

The Model 3000 Signal Generator is a rugged, solid-state signal source in the VHF frequency range (1 MHz to 520 MHz) with frequency accuracy of 0.001% and 1 kHz resolution. Internal and external AM and FM modes of operation and a calibrated output from +13 dBm to −137 dBm further increase the instruments versatility.

The accuracy of 0.001% results from internally phase locking the voltage controlled oscillators to various reference frequencies that are in turn referenced to a precision crystal-controlled oscillator.

Frequency is set with 1 kHz resolution via six front panel indicator switches or it can be remotely programmed by digital input. These features make the Model 3000 Signal Generator ideally suited for both semiautomatic and fully automatic test applications. Commonly available controllers or custom designed test fixtures used in conjunction with the Model 3000 can result in tremendous production test savings and at the same time minimize the typical human errors associated with repetitive type measurements.

The Model 3000 features both internal and external amplitude and frequency modulation. Internal modulation is selectable at a 400 Hz or 1 kHz rate. In the FM mode, peak deviations of 50 kHz or 500 kHz are attainable. In the AM mode of operation, amplitude modulation to 70% is attainable with minimum distortion. The frequency deviation of the FM modulating signal or percent of the amplitude modulation is regulated by a calibrated front panel slide-control potentiometer. In the vernier mode (dc modulation), this same slide control allows manual adjustment of the signal for convenient frequency or amplitude variations.

The output power is monitored on a front panel meter calibrated in both dBm and volts. A fifteen position, 10 dB step attenuator used in conjunction with a 11 dB vernier control provides a range of +13 dBm to −137 dBm. The calibrated output of the Model 3000 is leveled to within ±0.75 dB across the complete frequency range of the instrument.

Exceptional performance and ease of operation are key features of this low cost unit. The versatile Model 3000 gives accuracy, stability, dynamic range, and AM/FM capability that can be found only in instruments two to three times the selling price of the Model 3000.

FREQUENCY

Range
1 MHz to 520 MHz selectable in 1 kHz steps.

Readout
6 digit lever/indicator switch.

Resolution
1 kHz.

Fine Tuning
Vernier adjustment of up to 500 kHz.

Accuracy
CW and AM modes: 0.001%.
FMx1 mode: 0.001% ±10 kHz.
FMx10 mode: 0.001% ±45 kHz.

Stability
CW and AM modes: <0.2 PPm/hour.
FM modes: 500 Hz per 10 min.

RF OUTPUT

Impedance
50 ohms (SWR<1.2).

Power Level
+13 dBm to −137 dBm (1 V to 0.03 μV).

Attenuation
Continuously adjustable from +13 dBm to −137 dBm, in 10 dB steps and an 11 dB vernier. Output level is indicated on a front panel meter calibrated in volts and dBm.

Total Level Accuracy
±1 dB from +13 dBm to −7 dBm.
±1.7 dB from −7 dBm to −77 dBm.
±2.5 dB from −77 dBm to −137 dBm.
Total level error consists of
Flatness error:
±0.75 dB from + 13 dBm to −7 dBm.
Meter error:
±0.25 dB.
Step attenuator error:
±0.5 dB from 0 to −70 dB (and ±0.2 dB calibration error).
±1.0 dB from 0 to −130 dB (and ±0.5 dB calibration error).

SPECTRAL PURITY

Harmonic Output
>30 dB below fundamental from 10 MHz to 520 MHz.
>20 dB below fundamental from 1 MHz to 10 MHz.

Residual FM
Typically less than 200 Hz.

Residual AM
>60 dB below carrier in a 50 Hz to 15 kHz post detection noise bandwidth.

AMPLITUDE MODULATION

Frequency
Internal: 400 Hz and 1 kHz ±10%.
External: DC to 20 kHz; input level required, 10 V p-p into 600Ω to provide calibrated % modulation control.

Range
0% to 70%.

Distortion
3% for modulation levels to 70% at frequencies to 1 kHz.

Modulation Control
Calibrated from 0% to 100%.

Accuracy
±5% full scale.

FREQUENCY MODULATION

Frequency
Internal: 400 Hz and 1 kHz ±10%.
External: DC to 5 kHz; input level required, 10 V p-p into 600Ω to provide calibrated deviation control.

Deviation (Peak)
Two bands: 0 kHz to 50 kHz; 0 kHz to 500 kHz.

Deviation Control
Calibrated from 0 kHz to 50 kHz, X 1 and X 10.

Accuracy
±2.5 kHz on X 1 range.
±35 kHz on X 10 range.

PROGRAMMABILITY

Frequency
Frequency is digitally programmable via rear panel input connector. Control is by standard 8-4-2-1 BCD contact closures.

GENERAL

Output Connector
Type N.

Power
115/230 V ±10%; 50/60 Hz.

RF Interference
Meets MIL-I-6181 D.

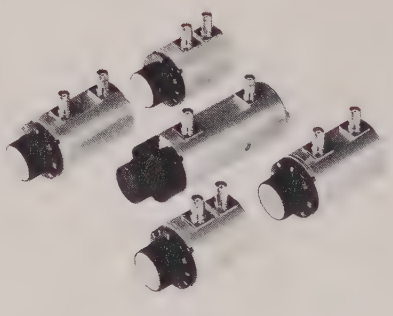
Dimensions
12 in./30.5 cm wide, 5¼ in./15 cm high, 13¾ in./35 cm deep.

Weight
25 lb/12 kg net, 30 lb/13.6 kg shipping.

Send for more detailed specifications.

ORDER INFORMATION
(FOB Beech Grove)
Model 3000 **$1795**

SERIES 5000/7500 ATTENUATORS



- **BROADBAND OPERATION**
- **LOW VSWR**
- **HIGH REPEATABLE ACCURACY**
- **IDEAL FOR SYSTEMS MANUFACTURERS, PLANT, AND FIELD USE**

The Series 5000 and 7500 Attenuators are miniature turret type units that operate over wide frequency ranges making them equally suitable for bench setups, field use, or incorporation into test instrumentation.

Units having 1 dB, 10 dB, and 70 dB of attenuation, variable in 0.1 dB, 1 dB, and 10 dB steps, are available in either 50 ohm or 75 ohm versions. The 10 dB and 70 dB 5000 Series units (50 ohms) cover the dc to 2000 MHz frequency range and the 7500 Series units (75 ohms) cover the dc to 1000 MHz range. The VSWR of all units is less than 1.2 to 1000 MHz. The 7500 Series attenuators, designed primarily for the CATV industry, have VSWR's of less than 1.1 to 500 MHz (26 dB return loss).

The Models 5080 and 7580 are dual concentric type attenuators that provide a total of 80 dB attenuation, variable in 1 dB steps.

All units are direct reading, ruggedly constructed, and have provisions for panel mounting.

SERIES 5000 ATTENUATORS

Frequency Range
DC to 2000 MHz.
DC to 1200 MHz (Model 5001).

Impedance
50 ohms.

VSWR
1.2:1 to 1000 MHz.
1.5:1 to 2000 MHz.
1.25:1 to 1200 MHz (Model 5001).

Connectors
Type BNC female, 50Ω.
Note: Type SMA, TNC, and N connectors available on special order.

SERIES 7500 ATTENUATORS

Frequency Range
DC to 1000 MHz.

Impedance
75 ohms.

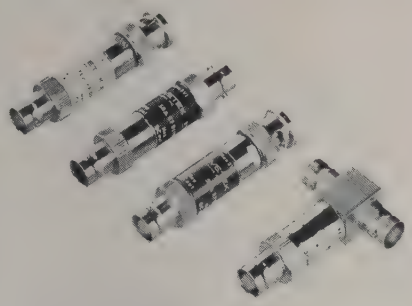
VSWR
1.1:1 to 500 MHz (26 dB return loss).
1.2:1 to 1000 MHz (21 dB return loss).

Connectors
Type BNC female, 75Ω.
Note: Type F connectors available at no increase in cost.

MODELS	5001	5010	5070	5080
Attenuation (dB)	0-1	0-10	0-70	0-80
Steps (dB)	0.1	1	10	1
Insertion Loss (dB)	1 dB ±0.3	0.3	0.4	0.7
Accuracy (dB)	±0.1 to 1200 MHz	±0.2 to 500 MHz ±0.3 to 1000 MHz ±1.0 to 2000 MHz	±0.3 to 500 MHz ±1.0 to 1000 MHz ±2.0 to 2000 MHz	±0.5 to 500 MHz ±1.0 to 1000 MHz ±3.0 to 2000 MHz
Max Input Power (Watts)	3	1	0.5	0.5
Angle between Steps (degrees)	30	30	45	30 (10 dB) 45 (70 dB)
Size Dia:	1-7/8 in./4.8 cm			
Length:	2-1/8 in./5.4 cm	2-3/4 in./7 cm		4-3/16 in./10.3 cm
Price (FOB Beech Grove)	$80	$80	$80	$185

MODELS	7501	7510	7570	7580
Attenuation (dB)	0-1	0-10	0-70	0-80
Steps (dB)	0.1	1	10	1
Insertion Loss (dB)	1 dB ±0.2	0.2	0.3	0.5
Accuracy (dB)	±0.1 to 1000 MHz	±0.2 to 1000 MHz	±0.5 to 500 MHz ±1.0 to 1000 MHz	
Max Input Power (watts)	3	1	0.5	0.5
Angle Between Steps (degrees)	30	30	45	30 (10 dB) 45 (70 dB)
Size Dia:	1-7/8 in./4.8 cm.			
Length:	2-1/8 in./5.4 cm	2-3/4 in./7 cm		4-3/16 in./10.3 cm
Price (FOB Beech Grove)	$90	$90	$90	$195

SERIES 150/170 RF DETECTORS



- **FLAT RESPONSE**
- **LOW VSWR**
- **REVERSE POLARITY CAPABILITY**
- **IDEAL FOR LABORATORY AND FIELD USE**

The Series 150 and 170 Detectors are designed for applications requiring low VSWR and flat frequency response across broad operating ranges.

The Models D151 and D152 are 50 ohm units with typical VSWR's of 1.2 at 1000 MHz. Both units have BNC male input connectors (RF) and BNC female output connectors (DC). The D151 has a 1000 MHz upper limit and the D152 can be operated up to 2 GHz.

The Model D171 is a 75 ohm detector that operates over the frequency range of 200 kHz to 1000 MHz with a response of ±0.3 dB and a return loss of greater than 23 dB. This is accomplished through use of the Wavetek designed 75 ohm BNC connector and associated frequency compensating circuitry.

For ease in mating with cable assemblies, 50 and 75 ohm units are available with BNC female connectors or both input and output ports.

The Model M151 is a three port, high impedance detector designed to obtain amplitude versus frequency response of an RF circuit with minimum circuit disturbance. It may also be used as an external monitor to level the sweep signal at the input junction of any device under test.

MODELS	D151	D152	D171	M151
Frequency Range (MHz)	0.2 to 1000	0.2 to 2000	0.2 to 1000	0.2 to 1000
Impedance (ohms)	50	50	75	50
VSWR	1.15 to 1	1.5 to 1	1.15 to 1 (23 dB return loss)	1.5 to 1
Max Input (volts)	3.0	3.0	3.0	3.0
Output Polarity*	Negative	Negative	Negative	Negative
Frequency Response (dB)	±0.3	±0.5	±0.3	±0.5
BNC Connectors				
RF Input	Male	Male	Male (75Ω)	Female
DC Output	Female	Female	Female	Female
Size **Dia:**	9/16 in./1.4 cm			
Length:	2-1/4 in./5.7 cm			
Price (FOB Beech Grove)	**$55**	**$75**	**$55**	**$75**

*May be reversed by reversing diode.

MODELS M157/M175 MATCHING PADS

- **BROAD FREQUENCY RANGE**
- **LOW VSWR**
- **SMALL SIZE**

Most RF communication equipment is designed for 50 ohm transmission, although several 75 ohm applications do exist in CATV and other related areas. All of the standard Wavetek Sweep/Signal Generators are available with either 50 ohm or 75 ohm calibrated output systems. For equipment that does not have this feature, matching pads are available to transform the impedance levels.

Frequency Range
DC to 1000 MHz.
Impedance
50 ohms to 75 ohms.
VSWR
1.15 to 1.
Insertion Loss
5.7 dB ±0.1 dB.
Maximum Input Power
1 watt.
BNC Connectors
50Ω male, 75Ω female M157
50Ω female, 75Ω male M175

ORDER INFORMATION (FOB Beech Grove)
Model M157 **$25**
Model M175 **$25**

MODELS B171/B172 DC BLOCKS

- **PREVENTS EQUIPMENT DAMAGE**
- **LOW VSWR**
- **MINIMUM INSERTION LOSS**

DC Blocks are designed to stop dc and attenuate any 60 Hz signals that are present in a signal while passing the RF portion with minimum insertion loss or additional VSWR.

CATV line amplifiers are commonly powered through the RF cable itself. This voltage can cause severe damage when connected to 75 ohm systems not having internal dc blocking networks.

Model B171 is ideally suited for series insertion into any existing line having a BNC connector while the B172 cable/block assembly is suited for permanent mounting in test equipment as a precaution against burnout. The standard B172 is supplied with a 9 inch cable (other cable lengths are available on special order).

Frequency Range
1 MHz to 1000 MHz.
Impedance
75 ohms.
VSWR
1.1 to 1.
Insertion Loss
0.2 dB.
DC Breakdown Voltage 100 V.
BNC Connectors
75Ω male and female B171
75Ω male and panel mounting female B172
Size
Dia.: 9/16 in./1.4 cm.
Length (with BNC and cable):
1-7/8 in./4.8 cm B171
9 in./22.8 cm B172

ORDER INFORMATION (FOB Beech Grove)
Model B171 **$30**
Model B172 **$30**

TV SWEEP GENERATORS

Wavetek provides specialized Sweep Generators for the Radio and TV Industry. These solid-state, programmable instruments include functions and options to more rapidly and accurately align, test, and evaluate receivers and components (tuners, amplifiers, etc.).

- **IF**
- **CHROMA**
- **SOUND**
- **VHF**
- **UHF**

1700 SERIES: COMBINATION VHF-UHF SWEEP GENERATORS

These units provide both VHF and UHF coverage in a single instrument. They may be used for manual operation or for automatic tracking of the tuner or receiver under test. When used in this manner, the 0-20 dB PIN diode attenuator automatically adjusts itself, maintaining a constant voltage at the detector. A readout is included for gain (loss) measurements.

This series also includes internal programming whereby a single contact closure from the users test fixture will program the following functions: UHF-VHF band switching, any combination of markers, 60 or 30 Hz (50-25) sweep rate, automatic attenuation and/or frequency, any range of tuning voltage for varicap tuners, and a time shared method of multiple displays for varicap type of tuners.

The series includes the 1701 (the U.S. only version). This unit will accept options providing 70-detent operation with video and sound markers on all 82 VHF and UHF TV channels. This is ideal for the mechanical tuner use of today.

This unit will also accept a CATV option adding detent programming with video and sound markers for the lettered channels A thru W in addition to the broadcast TV channels.

The 1702 is ideal for varicap or continuously tunable tuners for the U.S., but more specifically for the export market.

This unit will accept up to 16 RF markers and up to 4 intermixed standards for IF tracking markers.

Frequency Range
VHF 1 to 300 MHz
UHF 450 to 950 MHz

Sweep Width
VHF 1 to 300 MHz
UHF 1 to 500 MHz

Output
0.7 V rms (both bands), 75 ohms.

Attenuation
Separate UHF-VHF output systems with 0-35 dB in 5 dB steps plus 0-20 dB PIN diode variable.

Markers
1701 Up to 8 birdies plus picture and sound pulses on VHF
1702 Up to 16 birdies

1400 SERIES: VHF TV-CATV SWEEP GENERATORS

The 1400 Series covers the 1 to 300 and 1 to 400 MHz frequency bands. The 1402 provides detent programming of frequency and pix-sound markers for IF and channels 2 to 13, or IF, 2 to 13, and CATV channels A thru W. The 1403 is a continuously tuned VHF sweeper and will accept Wavetek automatic frequency and automatic attenuation options. Local oscillator tracking marker options are also available.

Frequency Range
1402 1 to 400 MHz
1403 1 to 300 MHz

Sweep Width
1402 1 to 50 or 1 to 400 MHz, selectable
1403 1 to 300 MHz

Output
1402 1.0 V rms, 75 ohms
1403 0.7 V rms, 75 ohms

Attenuation
1402 & 1403 0-35 dB in 5 dB steps plus 0-20 dB PIN diode variable (0-70 dB option)

Markers
1402 Pix and sound crystal-controlled pulses on IF, 2 to 13, A to W
1403 Up to 8 single frequencies or harmonic crystal-controlled birdies

1500 SERIES: UHF SWEEP GENERATORS

The 1500 Series covers the 450 to 950 MHz UHF frequency range. Three units are available. The 1503 provides a continuously tunable sweeper which will accept the Wavetek automatic frequency, automatic attenuation, and local oscillator tracing options. The 1504 is the same as the 1503 plus will accept the 70-detent option providing picture and sound markers on all UHF channels along with a 70-detent programmer and electronic channel readout. This unit is the industry standard for the FCC required 70-detent tuner. The 1550 is an economical version of the 1503 without the automatic and marker options.

Frequency Range
450 to 950 MHz.

Sweep Width
1 to 500 MHz.

Output
0.7 V rms, 75 ohms.

Attenuation
0 to 35 dB in 5 dB steps plus 0-20 dB PIN diode variable (0-70 dB option).

Markers
1503 Up to 8 single frequency or harmonic birdies
1504 Up to 4 single frequency or harmonic birdies plus picture and sound on all 70 UHF channels
1550 None provided

1300 SERIES: IF-RF SWEEP GENERATORS

The 1300 Series provides an extremely stable sweep source with accurate, crystal-controlled, pulse type markers. Most consumer product IF and radio RF bands are available. The 1301A provides IF sweep functions for TV receiver alignment and evaluation. Optional features available for this instrument allow rapid, accurate trap alignment and CW signals for chroma generation. This unit is also completely programmable.

Frequency Range

1301A	24 to 54 MHz
1312	4.5, 5.5, 6.0, 6.5, 10.7, or 88 to 108 MHz
1312D	Any single TV-VHF channel

Sweep Width

Adequate for specialized band covered by the instrument.

Output

1 V rms, 75 ohms.

Attenuation

99 dB in steps of 3, 6, 10, 20, 20, and 20 dB plus 0-20 dB PIN diode variable (0-30 dB in 1312).

Markers

Up to 5 (10 in 1301A) crystal-controlled pulse type markers with 0 to ±35 V amplitude.

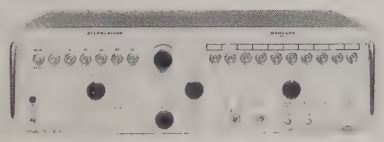
30 SERIES: DISTRIBUTION AMPLIFIERS

The 30 Series allows the in-plant distribution of sweep signals from the 1300 Series sweepers. They act as high impedance bridging amplifiers, sampling the distribution line, amplifying and leveling for a high output, flat (±0.25 dB) sweep signal. They will compensate for as much as 37 dB of line and return loss. An unlimited number of amplifiers may be used, since each amplifier acts as a master sweep source.

Frequency Range

32	25 to 50 MHz
	88 to 108 MHz
32B	5 to 110 MHz
33, 35	25 to 50 MHz

200-300 SERIES: IF-VIDEO SWEEP GENERATORS



Three rack mount units cover the TV IF and video frequency range. Model 301 is the basic unit covering the IF spectrum. This unit provides up to 10 crystal-controlled pulse type markers and will accept the Wavetek trap and chroma options. Model 201 video sweep is the 301 plus a video translator. The fixed frequency of the translator is a crystal-controlled signal at the video carrier of the standards ordered; i.e., 45.75 U.S., 38.9 CCIR. In this manner, the crystals of the 301 and 201 are interchangeable. 41.25 becomes 4.5 and 42.17 becomes 3.58 in the 201.

The 310 provides both video and IF outputs thru two output attenuation systems. This unit is very economical for incoming inspection, quality control, low volume manufacturers, or the engineering laboratory, where both signals are needed.

Frequency Range

201	0 to 10 MHz
301	25 to 55 MHz
310	0 to 10 MHz
	25 to 55 MHz

Sweep Width

201	2 to 10 MHz
301	2 to 15 MHz
310	2 to 10 MHz, Video
	2 to 15 MHz, IF

Attenuation

0 to 99 dB in steps of 3, 6, 10, 20, 20, and 20 dB plus 0-20 dB variable.

Markers

Up to 10 crystal-controlled pulse type markers (0 to 35 V amplitude).

400 SERIES: VHF SWEEP GENERATORS

The 400 Series provides detent operation at each and every channel for the standards ordered. Every standard around the world is available with picture and sound markers on all channels. Switching is all electronic, providing exceptionally long life and reliability, unlike the obsolete system of switching lumped constants.

Optional features are provided for:

1. Expanded view, base line, local oscillator tracking.
2. IF conversion, local oscillator tracking.
3. Up to 7 markers on the IF position.
4. Remote control.
5. Dual output systems.

Differences in the models are:

430	Rack mount version accepting all options
455	Basic portable VHF sweep with remote control and any one option
460	Portable VHF sweep accepting any one option (except remote controls)

Send for Catalog TV-74 for complete information and specifications.

SERIES 700 PHASE METERS

INTRODUCTION

Measurement of phase is an increasingly important function. The Wavetek 700 Series Phase Meters offer precision at low price. Digital accuracy with unique hands-off circuitry and automatic programmable models for your systems applications. Your questions will be answered and requirements filled by the following information.

PHASE MEASUREMENT

In theoretical discussions of systems performance, two characteristics have always received equal emphasis: amplitude as a function of frequency and phase shift as a function of frequency. In actual practice, however, most systems evaluations have concentrated on measurement of amplitude (gain or attenuation) characteristics and have excluded the measurement of phase performance. There have been good reasons for this approach, since phase measurement has been a time-consuming process, requiring precise tuning or matching of signals, or computation of phase angle using data from several other types of measurements.

With technology now demanding more accurate performance prediction and tighter specifications, accurate phase measurement is assuming a greater role in day-to-day use. The evaluation of phase shift characteristics of amplifiers, servo control loops, filter networks, delay distortion of transmission lines, and power factor computations are only a few applications requiring precise phase measurements. The Wavetek 700 Series Phase Meters provide the accuracy and versatility to meet these requirements.

PHASE MEASUREMENT THEORY

Phase measurement essentially is a measurement of time. The phase angle of a waveform can be expressed as the ratio of the time from some fixed reference point on a waveform to the period of that waveform.

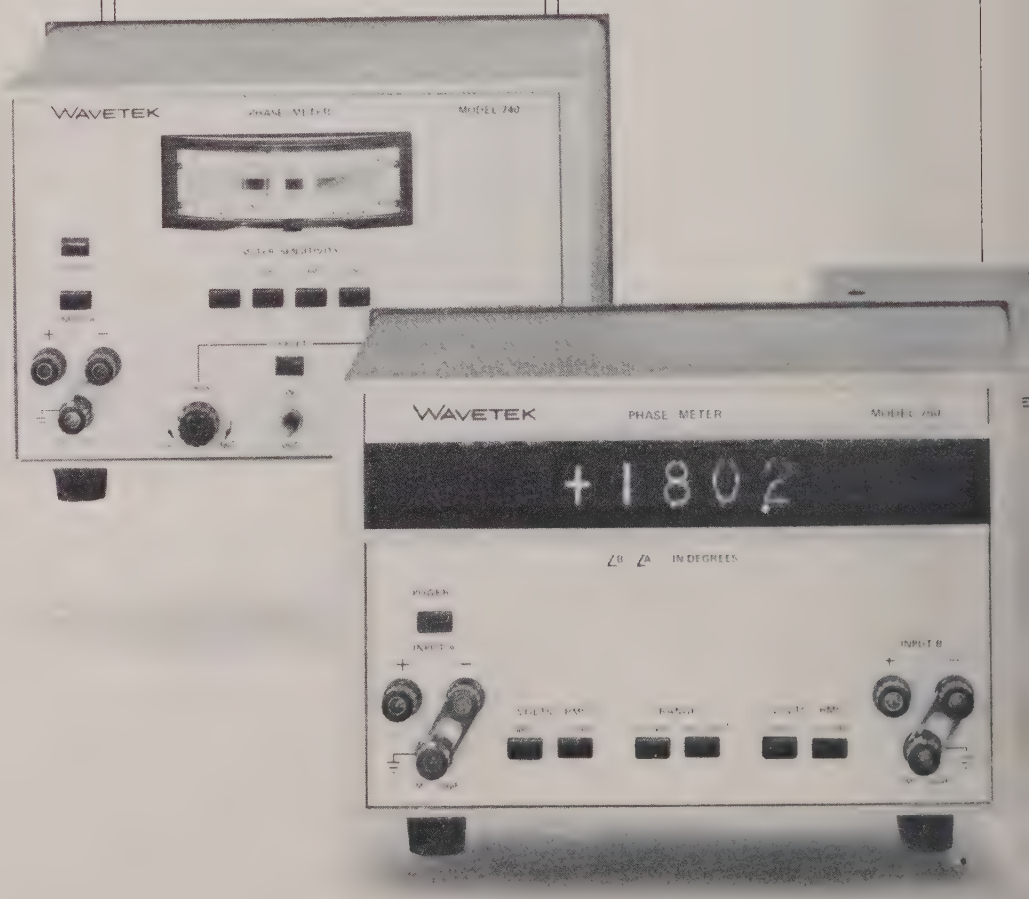
A phase meter measures the difference in phase angle between two signals, setting one channel as the reference and measuring the lead or lag of the other signal; e.g., if the two signals Y_1 and Y_2 are

$Y_1 = \text{Sin}\,(\omega t + \alpha)$

$Y_2 = \text{Sin}\,(\omega t + \beta)$

then the phase difference θ between the two signals can be expressed $\theta = \beta - \alpha$.

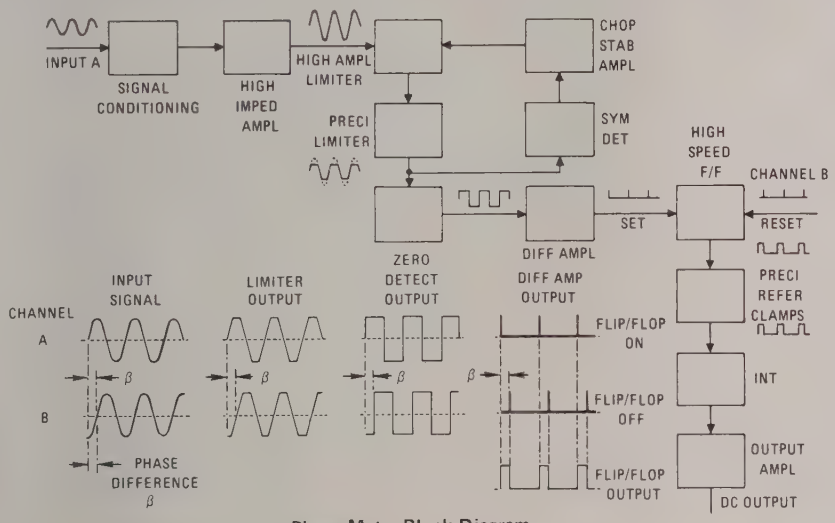
The measurement of the phase angle between two signals started with observation of the lissajous pattern on an oscilloscope. Other techniques involved the use of a time interval counter and computing the phase angle by the formula $\theta = t_d / T \times 360°$ where t_d is the measured time delay and T is the total period of the signal. Techniques that require precise matching of the amplitude of the two signals include: (1) multiplication, where the matched signals are multiplied and the result is averaged and read on a cosine scale meter; (2) vector techniques, in which the two signals are subtracted and converted to a Sin $\theta/2$ function; (3) phase discriminator techniques, where the signals are detected in a balanced transformer and rectified to a dc voltage, and (4) variable-delay line techniques which require phase shifting one signal until a null is reached.



The most widely used phase measurement technique is zero crossing. This method measures the time difference between zero crossings of the signal on each channel and converts this time difference into a phase-angle reading. This technique provides excellent accuracy and eliminates the need for tuning the frequency of the instrument or matching the amplitude of both channels. All Wavetek phase meters use the zero crossing technique.

The block diagram below is of a Wavetek 700 Series Phase Meter. Since both channels are identical, only the Channel A operation is shown. The signals are first attenuated or shifted 180° in phase as controlled by the front panel voltage range and phase range controls.

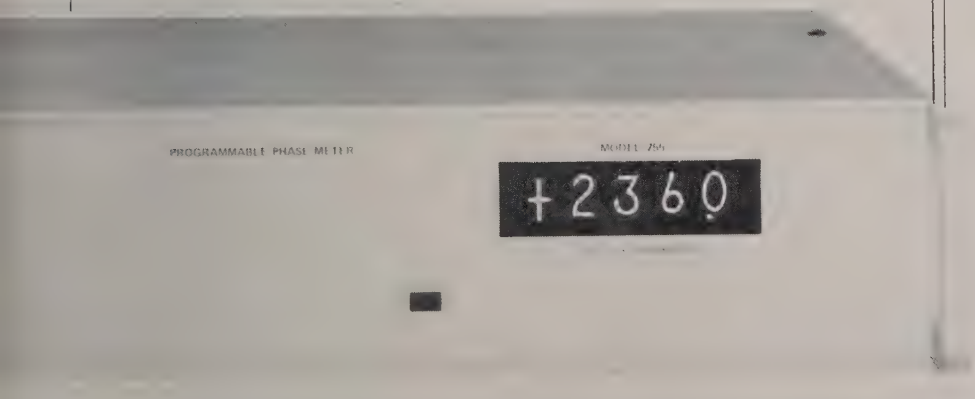
The input signal is amplified, then limited, as shown. The output of the limiter is a clipped sine wave and, if the proper zero reference was chosen, this waveform will have perfect symmetry. If the limiter has drifted or if the input signal is distorted, a phase measurement error will result. This error, however, also shows up as a nonsymmetrical square wave at the limiter output. In all Wavetek phase meters, the symmetry is measured at this point and any errors are detected and a correction is applied to the limiter. This eliminates errors due to this source. After the waveform is limited and converted to a square wave in the zero crossing detector, the signal is then differentiated and applied to the input of a high-speed flip flop (F/F). The signal from Channel A sets the F/F and the signal from Channel B resets the F/F resulting in a pulse train output from the F/F with a duty cycle proportional to the time differential between Channel A and Channel B zero crossings. This pulse train then drives a precision dc reference clamp and is integrated, giving a dc voltage proportional to the phase angle. The dc is then applied to the digital readout (Models 750 and 755) or the analog meter and offset circuitry (Model 740).



Phase Meter Block Diagram.

Wavetek phase meters have the following advantages over other phase measurement instruments:

1. The symmetry feedback loop compensates for zero detection errors, thus eliminating the major source of error due to input waveform distortion. It also allows the instrument to accurately measure sine waves, square waves, or pulse trains.
2. The wide band input limiters allow measurement over the widest possible dynamic range without amplitude matching.
3. The selectable phase range, or phase offset control, eliminates the ambiguity normally found at 0° or 180°.
4. The phase detection and reference circuitry operates in a ratio mode resulting in accurate stable measurements that are independent of power supply variations.
5. A convenient self-check calibration control on the rear panel allows the user to check the calibration accuracy of the instrument.



SERIES 700 PHASE METERS

PHASE MEASUREMENT ACCURACY

In evaluating phase-measurement accuracy, it is important to distinguish between absolute measurement accuracy (measurement deviation from the true value) and other accuracy statements having to do with relative accuracy, reading variation, or repeatability. The accuracy statements pertaining to the Wavetek meters refer to absolute measurement accuracy unless otherwise specified.

The accuracy of any phase measurement is dependent on many factors. The most important of these are signal frequency, amplitude, amplitude balance, and signal distortion or signal noise effects. Accuracy is a multidimensional problem.

Amplitude Effects On Accuracy

The following matrix lists the accuracies that can be expected with various combinations of input signal.

Absolute Accuracy (°)

Channel A Amplitude (% of range) \ Channel B Amplitude (% of range)	0.1%	1%	10%	100%
100%	±2.4°	±1.5°	±0.7°	±0.4°
10%	±1.5°	±0.7°	±0.6°	±0.7°
1%	±0.7°	±1.0°	±0.7°	±1.5°
0.1%	±1.5°	±0.7°	±1.5°	±2.4°

Notes:

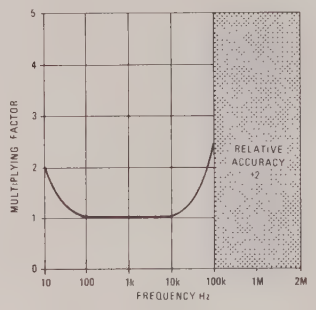
1. Absolute measurement accuracy includes calibration error, readout error, zero crossing accuracy, and zero shift errors.

2. Sine wave input.

3. 100 Hz to 10 kHz frequency range.

Frequency Effects On Accuracy

To determine the accuracy of the instrument over the operating range of 10 Hz to 100 kHz, the preceding data can be used together with the following figure. This provides the multiplication factor necessary to determine accuracy at other frequencies.



For example, when making a measurement at 50 kHz, the multiplication factor is 1.3. If the accuracy in the 100 Hz to 10 kHz range is 0.4°, the absolute accuracy at 50 kHz is 0.4° x 1.3 = ±0.52°.

Signal Effects On Accuracy

A square wave input results in the most accurate measurements. This is because the zero crossings are sharp and relatively easy to detect accurately. A sine wave which has a more gradual zero crossing is more difficult to measure. Any distortion will result in an error in zero crossing, resulting in a corresponding phase error. Wavetek phasemeters, however, use the unique symmetry detection loop system which measures errors of this type and feeds a signal back to cancel out errors due to even harmonic distortion.

Spikes or excessive noise on the input can cause errors. If the noise is substantial, it can trigger random zero crossings which result in a display that wanders or changes rapidly. These noise effects can be cancelled by proper filtering of the input signal.

WAVETEK PHASE METERS

All Wavetek phase meters utilize the same phase detection circuitry and operate on the same principal to the point where the phase is converted to a dc voltage. The differences between the several models are essentially one of display or readout features and controls as shown below.

Model	Frequency Range	Input	Remarks
740	10 Hz — 2 MHz	Differential	Phase offset & panel meter
750	10 Hz — 2 MHz	Differential	4 digit Nixie readout
755	40 Hz — 2 MHz	Differential	Digital & BCD readout

Model 740 Phase Meter

This instrument features a mirror-scale, front-panel display with scales of ±180°, ±60°, ±18° and ±6°. Phase offset capability allows the phase reading to be offset by as much as ±180° allowing all relative phase measurements to be made on the ±6° scale for highest resolution. The dc output can be fed to a digital voltmeter for display. Since the dc voltage is −10 mV per degree, the display on the digital voltmeter can be read out directly in degrees.

Model 750 Digital Phase Meter

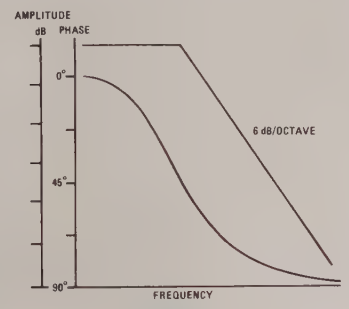
The Model 750 gives the ultimate in convenience and accuracy in a laboratory phase meter. The 4 digit readout displays the phase angle reading directly with automatic lead-lag indication. Resolution is 0.1° over the entire operating range. Two phase ranges, −180° +180° or 0° 360° eliminate ambiguous readings at range end points. Rear panel switches allow for instant calibration checks of the Model 750.

Model 755 Programmable Phase Meter

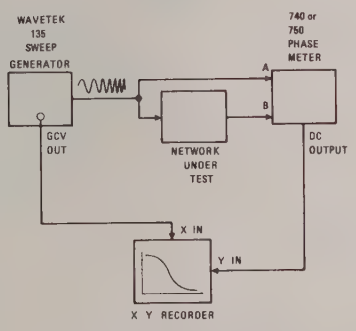
This phase meter uses the measurement and display system of the Model 750 and adds complete programmability of all functions. Designed specifically for systems or computer-controlled test applications, the phase reading is available at the rear connector in 8421 BCD format, TTL logic compatible. Phase ranging is automatically selected. The instrument can be programmed to read continuously or to read and hold until a computer command resets the instrument for the next measurement.

PHASE METER APPLICATIONS

The performance of any system can be described in terms of its transfer function, $G(j\omega) = Ae(j\omega t + \theta)$ where A = Gain or Attenuation, $j\omega t + \theta$ = phase angle. If this transfer function is known, the system output may be predicted for any input. Note that the amplitude as a function of frequency and the phase characteristics as a function of frequency are the only requirements. As an example, the characteristics of simple RC network are conveniently displayed in the format of a Bode plot. The test equipment shown can be used for a Bode plot of a network.



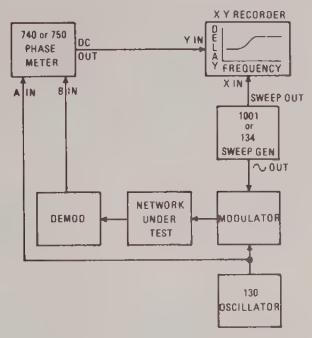
Bode Plot.



Bode Plot Test Connection.

This shows the setup for phase measurement. Replacing the phase meter with an ac voltmeter will give the amplitude characteristics for the same frequency range.

Delay distortion measurements in telephone network filters, transmission lines, and amplifiers can be accomplished using Wavetek phase meters as shown.

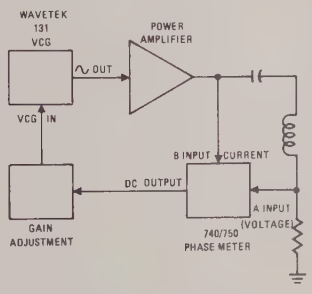


Delay Distortion Test.

The phase meter will measure the phase shift between the oscillator signal and the same signal after it has been modulated, transmitted through the network, and then demodulated.

Servo Control

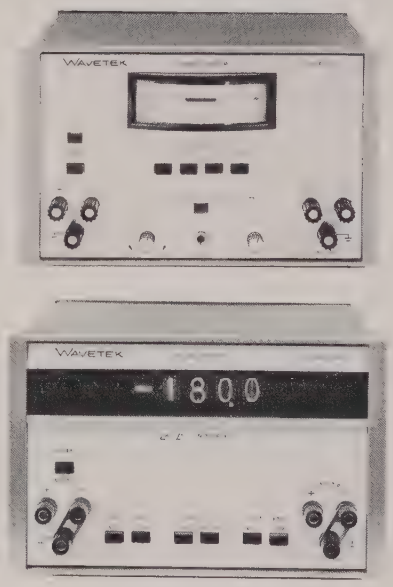
Servo control and phase locking can be accomplished in systems such as shown below. This application involves an ultrasonic welder in which the transducer tip is in



Servo Control System.

a phase lock loop in order to deliver maximum power. The capacitor is chosen to produce electrical resonance with the transducer coil. At this point the phase angle between the current and voltage is zero. If the transducer deviates from resonance, a phase angle shift is detected by the phase meter. The resulting dc output is fed through a divider into the VCG input of a Wavetek Model 131 Voltage Controlled Generator, changing the frequency and driving the transducer back to resonance.

MODELS 740 AND 750 PHASE METERS



The Wavetek Models 740 and 750 Phase Meters accurately measure the phase angle between any two ac signals with amplitudes between 1 mV and 300 V within the 10 Hz to 2 MHz range. Excellent sensitivity, broad dynamic range, wide bandwidth, and high precision are offered by these compact, easy to use instruments. High impedance differential inputs are used, and a dc output (−10 mV/degree) is provided for use in recording phase angle measurements or as a control signal for phase lock loops or servo systems.

The digital Model 750 has a four digit readout and the widest dynamic amplitude range available. The automatic operation of this instrument eliminates the need for amplitude matching, frequency tuning, and output filtering, resulting in true hands-off operation.

The Model 740 has a taut band meter readout and 360-degree phase offset capability. Resolution on both models is 0.1 degree.

Both instruments incorporate a unique closed loop design which eliminates most errors due to signal distortion and ensures stable, long-term phase measurements over varying temperature conditions.

ACCURACY

Absolute Measurement Accuracy

Calibration accuracy is ±0.1° with 20 Hz to 20 kHz square wave input between 100 mV and 5 V p-p.

Frequency Effects on Accuracy

With a sine wave input of 100% of amplitude range, accuracy is equal to calibration accuracy ±0.2° from 20 Hz to 20 kHz. Zero offset from 10 Hz to 100 kHz is less than 0.1° per 10 kHz. Relative phase accuracy (sameness in reading from one condition to another) from 100 kHz to 2 MHz is better than 2°.

Note: Rated accuracy applies throughout phase range except for 2° from range limits.

Amplitude Effects on Accuracy

Less than 1.5° for 60 dB change on both inputs.

Note: Minimum effect of signal amplitude on accuracy when input is below 20 Hz and above 50 kHz is when input is within 1% of amplitude range.

Waveform Effects on Accuracy

Errors due to even harmonic sine distortion are essentially eliminated by unique input detection circuitry.

Resolution

0.1°.

Drift

Less than 0.3° per 100 hours after one-half hour warm-up.

Response Time

Response time to a step input phase angle is 500 ms. For worst case change in amplitude (60 dB) and phase, maximum response time is 4 s.

INPUT SIGNAL

Amplitude Range

Model 740 50 mV to 50 V rms

Note: 1 mV to 2 V rms or 300 mV to 300 V rms available as an option.

Model 750 1 mV to 300 V rms

Note: Selectable in two overlapping ranges, 1 mV to 2 V and 300 mV to 300 V rms.

Frequency Range

10 Hz to 2 MHz.

Differential Measurement

True differential input. Input impedance is 2 MΩ shunted by 20 pF. When used single ended, the input impedance is 1 MΩ and 30 pF.

Maximum DC Voltage

Model 740 500 V

Model 750 100 V (2 V range)
500 V (300 V range)

Maximum AC Voltage

Model 740 120 V rms

Model 750 50 V rms (2 V range)
330 V rms (300 V range)

Common Mode Rejection

10 Hz to 100 kHz > 50 dB.
100 kHz to 2 MHz > 40 dB.

READOUT/CONTROLS

Model 740

Display

Meter readout with four selectable scales, ±6°, ±18°, ±60°, ±180°. (Meter accuracy ±2% of full scale.)

Recorder Output

−1.800 to +1.800 Vdc (−10 mV/degree) directly proportional to phase reading, output impedance 1 kΩ with stated accuracy.

Phase Offset Control

Phase offset control continuously variable from 0 to ±180° with coarse and fine adjustments.

Model 750

Display

Four digit Nixie readout +000.0° to +360.0° or −180.0° to +180.0° selectable, with automatic lead-lag (+ or −) indication.

Recorder Output

0 to −3.600 Vdc (−10 mV/degree, 0 to 360 range) or −1.800 to +1.800 Vdc (−180 to +180 range) directly proportional to phase reading, output impedance 1 kΩ with stated accuracy.

BCD Output (Optional)

8421 coded output available. Nominal logic levels, logic 1 = 1.6 V ±0.4 V, logic 0 = 0.2 V ±0.2 V from 10 kΩ source impedance.

GENERAL FEATURE

Phase Calibrate Switch (Rear Panel)

Allows the user to check range maximum and minimum calibration points. Rear panel access provided for calibration adjustments.

ENVIRONMENTAL

Specifications apply 25°C ±5°C, after one-half hour warm-up.

MECHANICAL

Dimensions

8½ in./21.6 cm wide, 5¼ in./13.7 cm high, 11 in./27.9 cm deep.

Weight

9 lb/4.1 kg net, 13 lb/5.9 kg shipping.

Power Requirements

100 V to 130 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 25 watts.

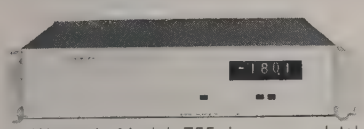
Note: Prices and specifications subject to change.

ORDER INFORMATION

(FOB San Diego)

Model 740	**$ 895**
Model 750	**$1495**
Options	
Amplitude Range (Model 740)	**$ 50**
BCD Output (Model 750)	**$ 100**

MODEL 755 PHASE METER



The Wavetek Model 755 is a completely automatic programmable digital phase meter intended for automatic phase measurement in systems applications. The instrument features the excellent sensitivity and broad dynamic range characteristics of all Wavetek phase meters, and adds the automatic and programming features required for automatic systems applications.

The wide dynamic range of Model 755 allows measurements to be made over a range of input signals from 1 mV to 300 V rms. Phase range is automatically selected to permit measurements of any phase angle without manual adjustment. The instrument may be programmed to update a phase angle reading upon receipt of a read command from an external source. Upon receipt of this command, the instrument will measure the phase angle and generate a print output command when the measurement is complete.

The automatic operation of the Model 755 Phase Meter makes it ideally suited for computer controlled test systems. Phase ranging and calibration controls may be operated manually from rear panel switches for added convenience during system checkout.

ACCURACY

Absolute Measurement Accuracy

Calibration accuracy is ±0.1° with 200 Hz to 20 kHz square wave input between 100 mV and 5 V p-p.

Frequency Effects on Accuracy

With a sine wave input of 100% of amplitude range, accuracy is equal to calibration accuracy ±0.2° from 200 Hz to 20 kHz. Zero offset from 40 Hz to 100 kHz is less than 0.1° per 10 kHz. Relative phase accuracy (sameness in reading from one condition to another) from 100 kHz to 2 MHz better than 2°. Readout scatter is approximately 0.4° at 100 Hz, 0.6° at 50 Hz, and 2° at 40 Hz.

Amplitude Effects on Accuracy

Less than 1.5° error per 60 dB input level change.

Note: Minimum sensitivity above 50 kHz is 1% of full scale selected. For frequencies above 20 kHz, Channels A and B should be programmed to the same range to eliminate attenuator phase delay.

Waveform Effects on Accuracy

Errors due to even harmonic sine distortion are essentially eliminated by unique input detection circuitry.

Resolution

0.1°.

Drift

Less than 0.3° per 100 hours after one-half hour warm-up.

INPUT SIGNAL

Amplitude Range

1 mV to 300 V rms, selectable in two overlapping ranges, 1 mV to 2 V and 300 mV to 300 V rms. Normally, in the latter range, lower range is programmable by remote command.

Frequency Range

40 Hz to 2 MHz.

Differential Measurement

True differential input. Input impedance is 2 MΩ shunted by 20 pF. When used single ended, the input impedance is 1 MΩ and 30 pF.

Maximum Peak (AC + DC Limit)

100 V (2 V range).
500 V (300 V range).

Maximum AC Voltage

50 V rms (2 V range).
330 V rms (300 V range).

Common Mode Rejection

40 Hz to 100 kHz>50 dB.
100 kHz to 2 MHz>40 dB.

READOUT/CONTROLS

Display

Four digit Nixie readout −180.0° to +360.0° with automatic lead-lag (+ or −) indication.

Recorder Output

−10 mV per degree dc voltage output directly proportional to phase reading, output impedance 1 kΩ.

Phase Ranges

Two phase ranges, −180° to +180° and 0° to 360°. Proper phase range is automatically selected when in auto range mode. Individual ranges may be selected manually by rear panel controls or remotely by computer program.

Note: Unit will auto range within approximately 10° to 20° of range limit. When in range select, measurements within 5° of range limit are not specified.

Response Time (Full Scale Change)

Analog: Less than 4 s
Digitizing: 1 s max
Auto Ranging: 2 s

GENERAL FEATURE

Phase Calibrate Switch (Rear Panel)

Allows the user to check range maximum and minimum calibration points. Remotely programmable for automatic calibration check.

ENVIRONMENTAL

Specifications apply 25°C ±5°C, after one-half hour warm-up.

MECHANICAL

Dimensions

19 in./48.3 cm wide (rack mount panel), 3½ in./8.9 cm high, 16½ in./41.9 cm deep.

Weight

11 lb/4.9 kg net, 22 lb/9.9 kg shipping.

Power Requirements

105 V to 125 V or 200 V to 250 V; 50 Hz to 400 Hz. Less than 25 watts.

Note: Prices and specifications subject to change.

INTERFACE DATA

Program Connector

1	1	Tenths
2	2	
3	4	
4	8	
5	1	Units
6	2	
7	4	
8	8	
9	1	Tens
10	2	
11	4	
12	8	
13	1	Hundreds
14	2	
15	±	
16	Read Command In	
17	Recorder Output	
18	Circuit Ground	
19	Print Command Out	
20	Range Program	
21	Range Min Calibrate	
22	Range Max Calibrate	
23	Channel 'A' Amplitude	
24	Channel 'B' Amplitude	

Notes:

BCD Output

8421 Output Code (TTL)
Logic 1 = +2.4 V nominally
Logic 0 = 0 V nominally

Computer Read Command Input

Accepts negative going pulse 2-10 V, 100 ns minimum width. Continuous read command available with rear panel switch.

Print Command Output

Pulse 0 (±0.4 V) to 2.4 V nominal when reading is available. 50 μs minimum width.

ORDER INFORMATION

Model 755 — $1995 (FOB San Diego)

MODEL 420 SWEEP-FREQUENCY TRANSMISSION TEST SET

The Model 420 is a swept-frequency transmission test set allowing level and impedance measurements across the voice and program frequency ranges from 50 Hz to 15 kHz. Level versus frequency is displayed on a CRT. This allows a single visual inspection of the transmission characteristic of the facility under test across entire frequency range.

Tests such as frequency run, hybrid network adjustment, equalization, bandpass, loss or gain, cable acceptance, and transmission faults on cable pair or on carrier channel can be performed with one instrument, faster and more accurately than with the test equipment you are now using.

Rugged and Light Weight

Designed for use anywhere without special handling.

Battery Option for Field Use

Long-life rechargeable batteries allow the instrument to be used anywhere; no need for converters or generators.

Transmitter/Receiver Separation

The transmitter and receiver are individually powered. This allows the transmitter to be used separately for end-to-end tests such as level and equalization.

Noise Option

Allows circuit noise with C message, 3 kHz flat, or 15 kHz flat to be measured without need of another piece of test equipment.

Cable Acceptance Testing

Performs all standard transmission tests required for cable acceptance in a telephone plant with one test instrument.

CRT Display

Instant determination of level or impedance at any frequency. Receiver will sync to any sweep or single frequency tone. Level and frequency of any external signal source easily determined.

Push Button Operation

Mode selection disables all other modes. The step-by-step instruction manual allows nontrained operator use.

Internal Hybrid

Network of 600Ω or 900Ω selected by push button. Terminals for precision nets are provided. An internal capacitance decade is provided for build out of precision nets.

Capacitance Bridge

For finding the length of cables, distances to opens or grounds, and capacitive unbalance of cable pairs.

Impedance Comparison

Dual trace for comparison of circuit impedance with known impedance or artificial line. Line under test is identified by interrupted trace.

Model 421 (European Version of the 420)

The Model 421 is identical with the model 420 except for the following special changes to meet European standards.

Siemans connectors.

Calibrates at 800 Hz.

Psophometric noise weighting filter instead of C message.

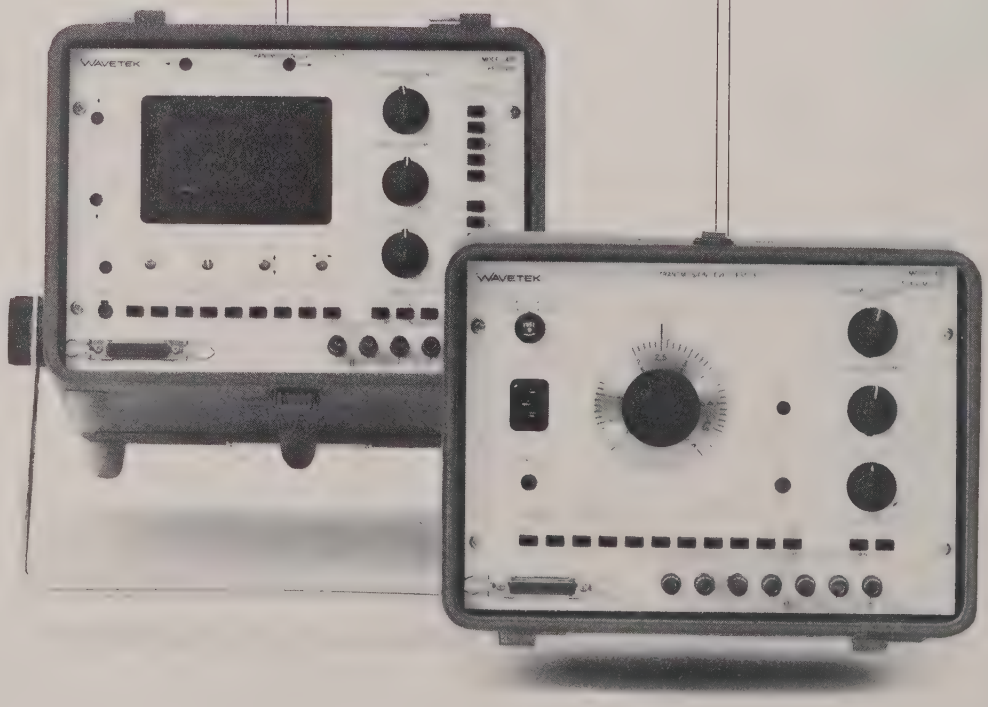
Noise dB instead of dBrn.

CCIT program weighting filter instead of 3 kHz flat.

Single frequency suppression.

220 volt standard power.

Note: Standard Options A, B, C, & D are available on the 421 with minor limitations. Please contact the factory for details on these limitations.



APPLICATIONS

Transmission Loss Measurements

Taking frequency runs on VF or data transmission facilities.

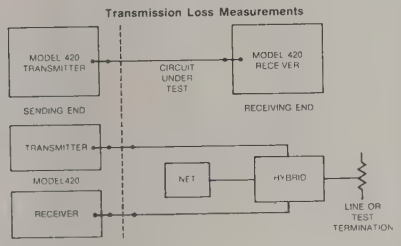
Finding loss or gain of circuit, CXR channel, or cable (end-to-end measurements).

Equalizing program channels or cable for flat response across the desired bandwidth.

Setting or checking gain, frequency response, and bandwidth gain devices.

Measuring return loss when using external hybrid or hybrid in 4-wire or CXR circuits.

Adjusting network of external hybrids or 4-wire to 2-wire VF repeaters.



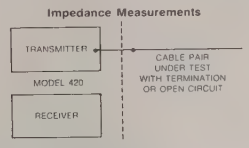
Impedance Measurements

Measuring impedance of cable facilities.

Determining impedance or resistance of terminating devices.

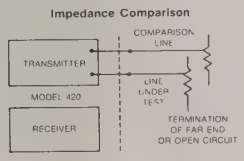
Locating trouble on loaded cable such as missing loads, bridge taps, opens, wets, and sections.

Checking input and output impedances of equipment, such as VF repeaters, repeat coils, and impedance compensators.



Impedance Comparison

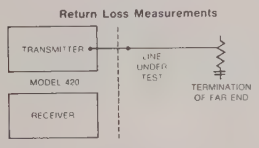
Comparing the impedance of a cable pair with the impedance of an artificial line for fault location.



Return Loss Measurements

Determining structural return loss by using the precision network in the hybrid of Model 420 and precision terminating the far end of facility or device.

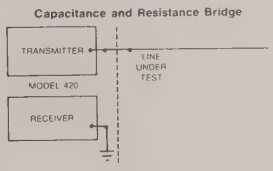
Measuring 2-wire return loss of any facility or device used in the transmission path of voice or program circuits.



Capacitance and Resistance Bridge

Measuring the capacitance of a cable pair to determine its length or location of open.

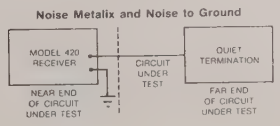
Measuring capacitive or resistive unbalance between tip and ground or ring and ground of a cable pair.



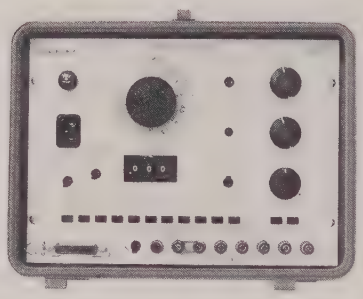
Noise Metallic and Noise to Ground

Measuring noise on any VF facility.

Measuring noise-to-ground to determine amount of power influence on the facility.


Noise Metalix and Noise to Ground
MODEL 420 RECEIVER
CIRCUIT UNDER TEST
QUIET TERMINATION
NEAR END OF CIRCUIT UNDER TEST
FAR END OF CIRCUIT UNDER TEST

MODEL 420



TRANSMITTER

Output

Sine wave output with two selectable frequency ranges:
50 Hz to 5 kHz.
150 Hz to 15 kHz.
Output level adjustable from +10 dBm to −50 dBm in 1 dBm steps.

Output Impedance

600Ω or 900Ω balanced.

Operating Modes

Cal: Instrument generates milliwatt source (1 kHz, 0 dBm).

Auto-Sweep: The transmitter generates a signal which is swept over the selected frequency range. Sweep rate is continuously variable with front panel control.

Manual Sweep: Instrument frequency is controlled manually by dial.

Impedance: 100Ω to 9000Ω in 4 ranges.

Return Loss: To −60 dBm.

Frequency Response

±0.2 dB for 50 Hz to 15 kHz.

Sine Distortion

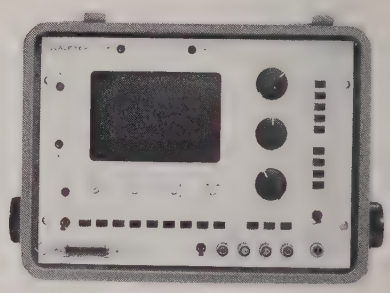
Less than:
1% for 50 Hz to 15 kHz.

Internal Hybrid Network

600Ω or 900Ω, resistive, with 600Ω and 2.15 μF or 900Ω and 2.15 μF compromise network removable by front panel ground strap. Terminals available for precision external network.

Holding Coil

Switchable in and out Approximately 2 henrys with 170Ω. 120 mA current capability.



RECEIVER/DISPLAY

Receiver Level

+33 dBm to −50 dBm.

Input Impedance

600Ω, 900Ω, or bridging, selected by front panel push button.

Calibration

Transmitter calibration signal of 1 kHz, 0 dBm.
Receiver adjusted by two front panel controls to 1 kHz at 0 dBm.

Frequency Response

±0.2 dB for 50 Hz to 15 kHz.

Holding Coil

Switchable in and out. Approximately 2 henrys with 170Ω.

Display

Correct scale is automatically displayed when measurement mode is selected. CRT screen is 2¼ in. high, 3⅜ in. wide. Display error: ±0.1 dB.

MECHANICAL

Dimensions

12 in./30.5 cm long, 9 in./22.9 cm high, 23 in./58.4 cm deep.

Weight

Less than 30 lb/14 kg in environmental aluminum case, 36 lb/16 kg with battery and noise options.

Power

115 V to 250 V; 50 Hz to 400 Hz. Less than 30 watts.

OPTIONS

Noise Measurement **Option A**

Noise in dBrn: Read as spot on display (−15 dBrn to +88 dBrn).

Noise Filters: C message, 3 kHz flat and 15 kHz flat, selectable, by front panel switch. Others available.

Noise Impedance: 600Ω, 900Ω, or bridging, selectable, by front panel push button.

Response: Front panel switch allows selection of normal or damped response for standard noise measurement.

Noise Monitor: Front panel jack plug for convenient monitoring of noise composition.

Noise-to-Ground: Front panel push button allows this measurement. (Ng dBrn is front panel dBrn plus 40 dBrn.)

Battery Power **Option B**

Provides rechargeable ni-cad battery power for transmitter and receiver. Transmitter battery life is 8 hours of continuous operation with a 14 hour charge. Receiver battery life is 2 hours continuous operation with a 14 hour charge.

Note: Standby status provided to extend the receiver operating time. "Battery low" lamp indicates battery at low level. Simultaneous charge and operation possible.

Impedance Comparison **Option C**

Allows two impedance vs frequency plots to be displayed for comparison. One trace is continuous and the other is dotted for easy identification.

Build-Out Capacitance **Option D**

0.001 μF to 1 μF in 0.001 μF steps. Use for build out, precision capacitance bridge, and fault location.

ADDITIONAL FEATURES OFFERED

Single Frequency Distortion Measurement: 0.2% to 10% range.

Single frequency suppression. (Any frequency or band of frequencies.)

Special output impedances.

Special frequency ranges.

Special weighting filter for noise and program.

Note: Please contact the factory for details on these or other special requirements you may have.

ACCESSORIES

Protective Cover

Rugged high-impact plastic cover for control panel protection when the transmitter and receiver are separated. Cover fits either receiver or transmitter.

Accessory Mount

Adapts the receiver CRT for the Hood, Tracing Overlays, and the Camera.

CRT Hood

For viewing in high ambient lighting. Use with the accessory mount. Made of soft, flexible rubber material.

Polaroid CR9 Camera and 33-9 Hood

For instant photographic records of CRT Display. Use with the accessory mount and Polaroid Type 104 Film Packs (8 3¼ X 4¼ prints).

Tracing Overlay

Reusable snap-in-place overlay for curve tracing. Overlay may be Xerox reproduced for a permanent record. Use with the accessory mount. Natural finish requires special marking pencil, etch finish requires soft pencil. Transparent plastic with dB and ohm scales. Blocks for recording switch settings.

Marking Pencil

For use with natural-finish tracing overlays formulated for high visibility, good adherence to overlays, and Xerox reproducibility.

Accessory Kit

Includes hood, 20 overlays, 2 pencils, and an accessory mount.

ORDER INFORMATION

(FOB San Diego)

Model 420		**$1995**
Options		
A	Noise Measurement	**$ 345**
B	Battery Power	**$ 300**
C	Impedance Comparison	**$ 125**
D	Build Out Capacitance	**$ 300**
Rack Mount		**$ 150**
Accessories		
420-367	Protective Cover	**$ 25**
420-038	Accessory Mount	**$ 45**
420-033	CRT Hood	**$ 30**
CR9 and 33-9	Polaroid Camera and Hood	**$199**
420-361N	Tracing Overlay (Natural Finish)	**$ 2**
420-361E	Tracing Overlay (Etch Finish)	**$ 2**
420-034	Accessory Kit	**$100**

Minimum Order: $15

ACCESSORIES AND OPTIONS

Most accessories and options which are peculiar to an individual instrument are listed with the instrument. Some of those accessories and options as well as equipment for systems manufacturers are indexed below. The rack mount option and rack adapter accessories, which are for most instruments, are covered here.

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Computer I/O Interface Cards (for Models 158 and 159)	37
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Remote Programming Unit (for Models 158 and 159)	37
RF Detectors	57

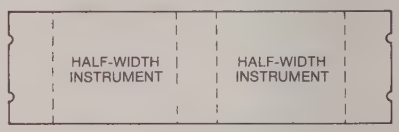
Wavetek offers a large number of accessories and options to help tailor your instrument to your individual needs. Several options are available when an instrument is to be mounted in a 19 inch standard rack. The instruments can generally be permanently rack mounted, or they can be supplied with rack adapter kits.

RACK MOUNTING

All 110 series, 130 series, and Models 142, 144, 740, and 750 can be ordered with factory-installed 5¼ inch rack mount panels. The rack mounted 110 series instruments feature rear connectors, and all others feature BNC feed-through connectors. The instruments are normally mounted in the center of the panel; however, the mounting may be offset to either side if specified at time of order.

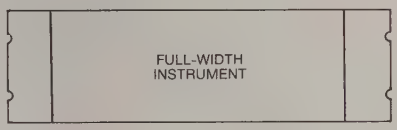
DUAL RACK MOUNTING

Any two of the instruments listed above under rack mounting may be ordered with a dual rack mount; i.e., two instruments side-by-side in a single rack panel. With two 110 series instruments in a dual rack panel, the panel height is 5¼ inches. All other combinations require a 7 inch panel since feed-through BNC connectors are used.



RACK ADAPTER KITS

Most of the instruments can be supplied with a rack adapter kit, which consists of hardware that can be attached to the instrument for 19 inch rack mounting. The kit is 5¼ inches high.



DUAL RACK ADAPTER KITS

All 110, 130, 1000, and 2000 series instruments plus Models 142, 144, 740, and 755 can be used with a dual rack adapter kit. These kits allow use of two instruments side-by-side in a 19 inch panel.

SPECIAL PAINT

Special painting of only rack-mountable instrument front panels is available. Paint may be furnished by Wavetek or customers.

ORDER INFORMATION

Rack Adapter Kit	
1000/2000/3000 Series	**$35.00**
All others	**$30.00**
Dual Rack Adapter Kit	
1000/2000 Series	**$40.00**
All others	**$30.00**
Rack-Mountable Model	
Models 110 and 111	**$75.00** plus instrument cost
All others	**$50.00** plus instrument cost
Dual Rack-Mountable Models	
110 or 110 with 110 or 111	**$125** plus instrument cost
110 or 111 with 112, 113, or 116	**$100.00** plus instrument cost
All other combinations	**$75.00** plus instrument cost
Special Paint	
Customer Furnished	**$15.00**
Wavetek Furnished	**$50.00**

SERVICE, WARRANTY AND SPARES

Service

Wavetek maintains a staff of technicians at its factories and various locations throughout the world to help you get the maximum use from your Wavetek instruments. These people are highly trained in the operation, maintenance, and calibration of Wavetek equipment and will assist you with any technical problems that might be encountered.

In-Warranty Repair

Should a malfunction occur with any Wavetek instrument, contact your nearest Wavetek representative. An apparent malfunction may be corrected over the phone by first contacting your local Wavetek representative or the Customer Service Department at the factory. Wavetek's representative will direct you to the nearest authorized service center or send a service technician to your facility for immediate correction of a malfunction. Do not send the instrument back to the factory without prior authorization. If it does become necessary to return an instrument to the factory or to the local Wavetek Service Center, any symptoms along with the your name and phone number should be written on a card and taped to the top of the instrument. In most cases, the instrument will be calibrated, certified, and reshipped within 48 hours after receipt at the factory.

Calibration

A comprehensive calibration procedure for periodic maintenance is contained in the manual sent with each instrument. Should recalibration of any Wavetek instrument become necessary in the field, an average instrument technician should be able to easily and quickly recalibrate it. If it becomes desireable or necessary to send the instrument to Wavetek for recalibration, the instrument should be properly packaged and shipped prepaid. If the instrument requires no repair and is accompanied by a Purchase Order for $35, the instrument will be calibrated, certified, and reshipped within 48 hours after receipt at the factory or local service center. If repair is required, you will be supplied with a formal quote and work will begin when authorization is received.

Out-of-Warranty Repair

Should it become necessary to return an instrument for repair, tape a card listing symptoms and your name and phone number on the top of the instrument prior to shipping. Within three working days after receipt at the factory, your instrument will be evaluated and you will be supplied with a formal quote. Repair will begin when authorization is received in the form of a Purchase Order. Your instrument will be reshipped to you within two working days after receipt of your Purchase Order. To further expedite an out-of-warranty repair, enclose a Purchase Order not exceeding $50 with your instrument. Wavetek gives a 90-day guarantee on all out-of-warranty repairs.

Refurbishment

After several years of service, you may have any standard Wavetek instrument returned and restored to original specifications at the appropriate Wavetek factory for a nominal charge. Write a Purchase Order for 20% of the purchase price of the instrument. Box the instrument and ship prepaid to the appropriate Wavetek factory:

Point of Manufacture:

San Diego Calif.
Function /Sweep Function Generators
Phase Meters
Transmission Test Sets

Beech Grove, Indiana
Sweep/Signal Generators
TV Test Equipment
RF Attenuators
RF Detectors

Addresses:

Wavetek
9045 Balboa Avenue
San Diego, CA 92123
Attention: Customer Service Dept.

Wavetek
66 North 1st Avenue
Beech Grove, IN 46107
Attention: Customer Service Dept.

SPARE PARTS PRICES—BOARD ASSEMBLIES

SPARES

Standard printed circuit module cards are available at a nominal cost to assist you in quick, easy maintenance and repair in the field. All module cards listed are available on 30 day delivery. To assure conformance and proper operation, specify the model number and serial number of the instruments for which the spare parts are being purchased.

Assembly	Model	Price
Main Board	110-116	$165
VCG Board	111-116	115
Trigger Board	112&114	95
Trigger Board	115&116	120
Mother Board	110&111	25
Mother Board	112, 114-116	60
Mother Board-Battery	110&111	60
1st Subpanel	110&115, 116	155
1st Subpanel	111&114	195
1st Subpanel	112	215
2nd Subpanel	114	195
2nd Subpanel	115	145
2nd Subpanel	116	185
Rear Connector Board	112-116	55
RM-Rear Connector Board	110&111	55
RM-Rear Connector Board	112-116	55
Power Supply-AC	110-116	105
Power Supply-Battery	110&111	205
Power Supply-Battery	112-116	190
Battery Pack	110-116	165
Extender Board Set (3)	110-116	45
	S.N. up to 017781	
Extender Board (1)	110-116	20
	S.N. 017781 & up	
Main Board	113	165
Power Supply-AC	113	105
Rear Conn. Board	113	50
Mother Board-Horiz.	113	45
Mother Board-Vert.	113	55
VCG Board	113	115
Front Conn. Board	113	45
Funct. & Atten. Sw. Board	113	95
Freq. Sw. Board 1st	113	60
Freq. Sw. Board 2nd	113	50
Freq. Sw Board 3rd	113	50
Hertz Mult. Sw. Board	113	100

Assembly	Model	Price
Assy. Bracket	130	$ 75
Assy. Bracket	131&134	75
Assy. Bracket	135&136	75
Main Board	130	260
Main Board	131	310
Main Board	134	275
Main Board	135	285
Main Board	136	310
Sweep Board	134	140
Sweep Board	135	155
Log Converter	135	200
X-Y Multiplier	136	200
Main Board	142	340
Power Supply	142	80
Main Board	144	365
Power Supply	144	80
Sweep & Trigger	144	200
Main Board	146	465
Power Supply	146	75
Switch Board	146	390
Auxiliary Board	146	155
Main Board	147	740
Readout Board	147	95
Sweep Board	147	555
Power Supply	147	300
Power Supply	150&155	90
D-A Converter w/o Logic	150&155	180
D-A Converter w/Logic	150&155	170
Sine Converter	150&155	100
Schmidt	150&155	80
Integrator	150&155	60
Range & Trigger	150&155	200
Output Ampl w/o Logic	150&155	245
Output Ampl w/Logic	150&155	210
Attenuator	150&155	50
Decade Logic	150&155	100
Function Logic	150&155	55
Range Logic	150&155	95
Frequency Logic	150&155	65
Extender Board	150&155	35
D-A Amplifier	154	110
D-A Converter	154	150
Main Board	154	575
Power Supply 6 V, 23 V	154	50
Power Supply 15 V, 24 V	154	65
Range Matrix	154	45
Transistor Mounting Board	154	25
VCG Board	154	130
Extender Board	154	20

Assembly	Model	Price
Extender Board	157	$ 55
Output Amplifier	157	350
Function Board	157	305
VCG/Integrator	157	290
Range Matrix	157	225
Error Amplifier	157	600
Crystal One Shot	157	390
Power Supply	157	155
Counter Board	157	310
Left Switch Board	157	40
Right Switch Board	157	35
Attenuator	157	110
Mother Board	157	175
Analog Board	158&159	440
Digital (Logic) Board	158&159	485
Front Panel Assy	159	400
Power Supply	158&159	220
Assy Bracket	740	85
Assy Bracket	750	125
Logic & Power Supply	740	230
Logic & Power Supply	750	240
Zero Crossing	740	330
Zero Crossing	750	375
Digital Board	750	275
Analog Board	750	185

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Seattle, WA 98108
Telephone: 206/763-2755

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Lawndale, CA 90360
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Sunnyvale, CA 94086
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8080 El Paseo Grande
La Jolla, CA 92037
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11161 New Hampshire Ave., Suite #103
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You can also return the attached card directly to Wavetek or contact the factories directly for information. For information regarding sweep/signal generators and television sweep generators, contact Wavetek Indiana; for function generators, phase meters and transmission test sets, contact Wavetek San Diego.

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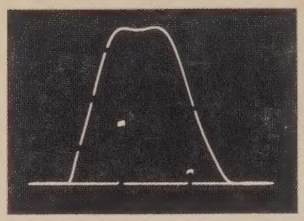
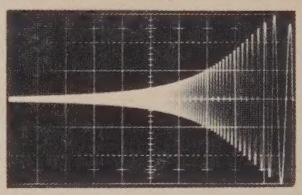
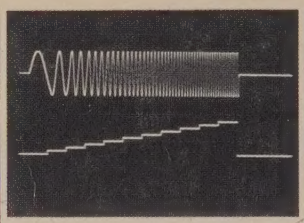
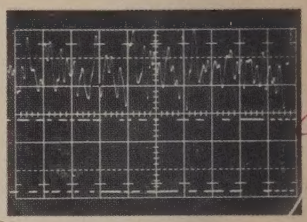
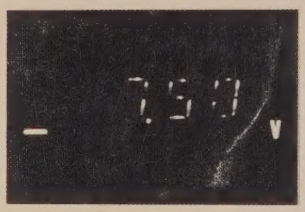

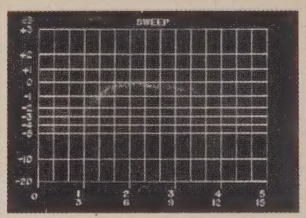

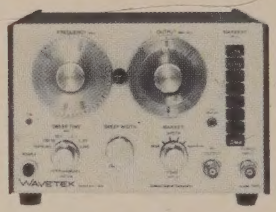

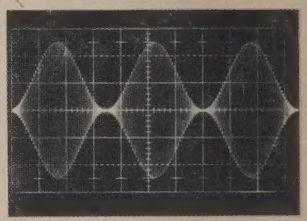
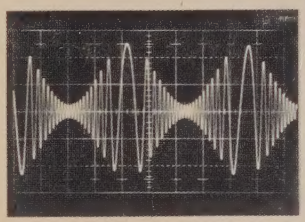
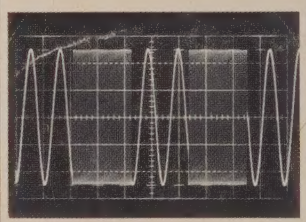
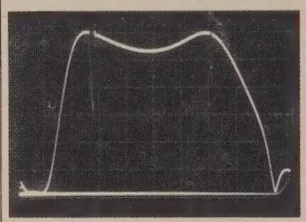
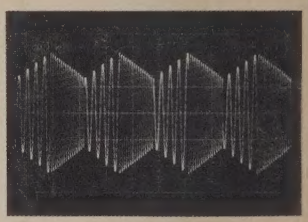
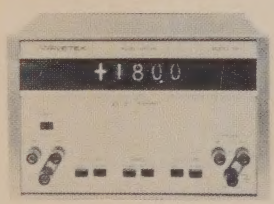

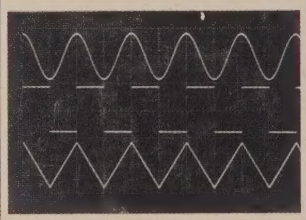
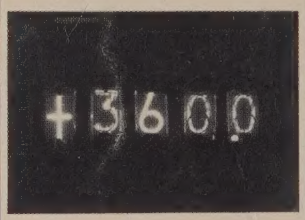

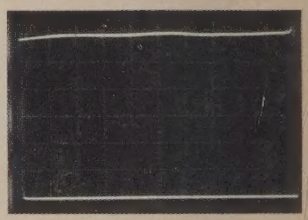
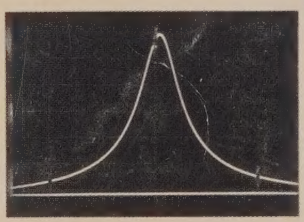
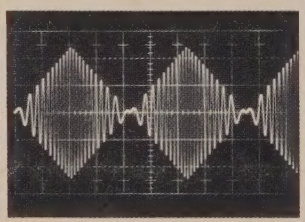
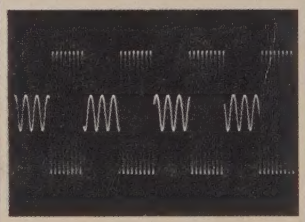
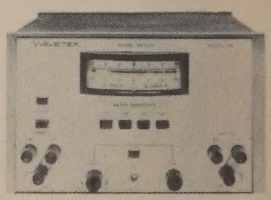
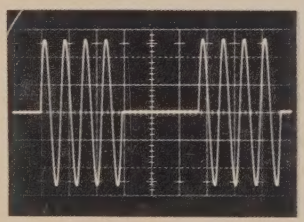
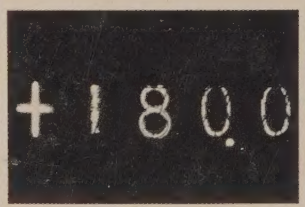

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